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RAMMATIC GUIDE SIGNS FOR USE ON TROLLED ACCESS HIGHWAYS.

III. Traffic Engineering Evaluation of Diagrammatic Guide Signs.

Part 2. The I-495 (Capital Beltway)/I-70S Field Study.

G.S. Kolsrud

DEPARTMENT OF
TRANSPORTATION

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December 1972
Final Report

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16. Abstract

The purpose of the diagrammatic signing research project was to develop warrants and standards for the use of diagrammatic guide signs on controlled access highways. Volume III of this report is published in 4 bound books - 1 book for each of its 3 parts, plus 1 book containing appendixes to Part 2. Part 2 contains the detailed description of a large-scale before/after field study, comparing the relative effectiveness of diagrammatic and conventional signing. It presents the approach, methods (Traffic Evaluator System or TES, time-lapse photography, and motorist questionnaires) as well as results. The 3 appendixes to Part 2 are in a separate book (RD-73-25). Part 1 of Vol. III. (RD-73-23) is a guide to and summary of Part 2. Part 3 (RD-73-26) presents review of other work, conclusions, and other discussion.

Research findings obtained under the project indicate that drivers require more time to read and interpret information on diagrammatic signs in comparison with conventional signs. Moreover, as the graphic component on the sign becomes more complex, driver information interpretation time increases. Accordingly, in those cases where diagrammatic signs have been recommended, the standards specify that simple graphic designs must be used. Research results clearly indicate that diagrammatic guide signs will produce a benefit to motorist performance at interchanges where traffic must exit to the left of the through route. Such interchanges include major forks where exiting traffic must take the left fork. Also included are interchanges where there is a single left exit from the roadway and where there is a left exit in combination with a right exit.

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FHWA-RD-No.	Vol. No.	Book title	Note on contents
73-21	I	Recommendations for Diagrammatic Guide Signs.	
73-22	II	Laboratory, Instrumented Vehicle, and State Traffic Studies of Diagrammatic Guide Signs.	
73-23	III	Traffic Engineering Evaluation of Diagrammatic Guide Signs. Part 1: Technical Overview of the I-495 (Capital Beltway)/ I-70S Field Study.	First of 3 parts, each issued as a separate book, with an additional book for Part 2 appendixes.
73-24	III	Traffic Engineering Evaluation of Diagrammatic Guide Signs. Part 2: The I-495 (Capital Beltway)/I-70S Field Study.	Second of 3 parts.
73-25	III	Traffic Engineering Evaluation of Diagrammatic Guide Signs: Appendixes A, B, & C to Part 2.	
73-26	III	Traffic Engineering Evaluation of Diagrammatic Guide Signs. Part 3: Synthesis and Conclusions.	Third (last) of 3 parts.

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PREFACE

This document is part of a three-volume series entitled *Diagrammatic Guide Signs For Use On Controlled Access Highways.* Volume III is divided into 4 parts, separately bound. Titles of all volumes with a capsule summary of their contents are shown below.

Volume I. Recommendations for Diagrammatic Guide Signs. Summarizes the entire diagrammatic signing research program sponsored by the Federal Highway Administration. Presents the recommended warrants, standards and guidelines for diagrammatic guide signs and the basis for the recommendations. Recommends techniques and measures for the evaluation of highway signing. Prepared jointly by the Office of Research, Federal Highway Administration and BioTechnology, Inc.

Volume II. Laboratory, Instrumented Vehicle and State Traffic Studies of Diagrammatic Guide Signs. Describes research on the relative effectiveness of diagrammatic and conventional signing as measured in the laboratory and in the field with an instrumented vehicle. Relevant research conducted by State Highway Departments and the results of a nationwide survey of diagrammatic guide signs are presented. Prepared by the Office of Research, Federal Highway Administration.

Volume III. Part 1. Traffic Engineering Evaluation of Diagrammatic Guide Signs: Technical Overview of the I-495 (Capital Beltway)/I-70S Field Study. Detailed treatment of the field study is provided in Part 2, a very large volume. Part 1 is designed to assist the reader of Part 2 to select those sections of particular interest. The most important conclusions of Part 2 are included. Prepared by BioTechnology, Inc.

Volume III. Part 2. Traffic Engineering Evaluation of Diagrammatic Guide Signs: The I-495 (Capital Beltway)/I-70S Field Study. Detailed description of a large-scale before/after field study comparing the relative effectiveness of diagrammatic and conventional signing. The approach, methods (Traffic Evaluator System, time-lapse photography and motorist questionnaires) and results are presented. There are three appendices. Appendix A, The Traffic Evaluator System, contains a detailed description of TES hardware and software and the use of this system in the field. Appendix B includes the questionnaire forms used in the study. Appendix C presents the frequency and percentage of drivers selecting each response category for each question by interchange and questionnaire form. Appendices A – C are bound as one document. Prepared by BioTechnology, Inc.

Volume III. Part 3. Traffic Engineering Evaluation of Diagrammatic Guide Signs: Synthesis and Conclusions. Compares the I-495/I-70S field study with other diagrammatic signing research. Several field measurement techniques, laboratory methods and traffic behavior models are evaluated for their utility in signing research. The volume concludes with cost-benefit considerations of diagrammatic and conventional signing and recommendations for future research. Prepared by BioTechnology, Inc.

PART 2

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CHAPTER I

INTRODUCTION TO PART 2

The purpose of route guidance signing on highways is to assist drivers to safely, efficiently, and easily reach their destinations. In 1967, roughly ten percent of the vehicle miles per year were registered on the interstate highway system for a total of 105 billion travel miles. The associated fatality rate was 3.15 per 100 million vehicle miles, a significant improvement over the 7.6 accident rate for all rural roads but still a sizable number (Automobile Manufacturers Association, 1969). These figures suggest that route guidance signing improvements can have a significant impact on safety, efficiency and ease of negotiating the interstate highway system.

Recently, there has been considerable interest in the possibility that signs incorporating a pictorial or diagrammatic view of highway interchanges might improve driver performance and decrease the accident rate. However, the vast mileage of the interstate system and the large number of route guidance signs associated with it mean that any proposed change in signing must be carefully evaluated. This is particularly important if accelerated replacement of existing signs by diagrammatics is contemplated. The considerable expense involved must be justified by anticipated benefit.

Unfortunately, much of the research reported on the relative effectiveness of diagrammatic and conventional signing has produced conflicting results or has been subject to the criticism that the results were confounded by extraneous variables. In addition, some of the research was conducted in the laboratory, and laboratory studies are inevitably questioned for their validity in the real world. Research conducted by other investigators is very briefly described in the next Chapter and is thoroughly reviewed in Part 3 of this volume. Suffice to say here, the need for a field evaluation of diagrammatic compared to conventional signing became essential and this project was undertaken to meet that need.

The study was conducted at a series of successive interchanges on two contiguous interstate highways: I-495 (the Capital Beltway) and I-70S. Two types of signs were evaluated: conventional signs meeting the standards set by the 1961 edition of the Manual on Uniform Traffic Control Devices; and a particular configuration of diagrammatic signs. Diagrammatic signs may be constructed in various ways. For example, the graphics may portray a plan view of the interchange or a perspective view. Also, within the series of guide signs provided for a particular interchange, diagrammatics may be presented at one or more signing locations. In this evaluation, the diagrammatic signs presented a plan view of the exit area. Diagrammatics replaced conventional signs at all route guidance sign locations within each test interchange. For a given interchange, the diagrammatic signs generally decreased in complexity from advance signs toward the gore.

Besides the field evaluation of the two types of signing, this project had several additional objectives. These included:

- Comparison of study results with results obtained by others; and generalization of conclusions on the effectiveness of diagrammatic guide signs to controlled access highways beyond those studied in this project.
- Comparative evaluation of the utility of several experimental techniques (e.g., the Traffic Evaluator System, time-lapse photography and laboratory methods) for guide signing research.
- Application of models of traffic behavior and assessment of their utility in evaluation of highway signing.
- Consideration of benefits and costs associated with replacement of conventional signs by diagrammatics (if warranted by the outcome of the field evaluation effort).
- Contributing to the development of standards, warrants and guidelines for diagrammatic signs if justified by the outcome of the study.

Relation of Part 2 to Parts 1 and 3

This is Part 2 of a three part series entitled *Traffic Engineering Evaluation of Diagrammatic Guide Signs*. Part 2 provides a very detailed description of the methods used and results obtained in the field evaluation. Coverage of the additional objectives listed above will be found in Part 3. Readers of Part 2 are urged to first review Part 1 which provides an overview of the contents of this volume and its major conclusions. Such a review will provide the reader with an orientation to Part 2 and allow him to select those chapters of particular interest.

CHAPTER II

APPROACH

The basic approach to the field study was a before/after comparison with conventional signing in the Before phase and diagrammatic signing in the After phase. The before/after approach has been used by other investigators of the relative effectiveness of conventional and diagrammatic signing. Four of these will be briefly mentioned here to provide the context for this study. For a detailed review of the literature, the reader is referred to Part 3.

The four studies were those conducted by Hanscom (1971), Roberts (1971), Snyder and Crossette (1969) and the Wyoming State Highway Department (undated). If results based on driver opinion are ignored (because opinion and performance data are not always consistent), the results of two of these studies tended to favor diagrammatic signs (Hanscom, 1971 and Roberts, 1971), one provided ambiguous results because of small sample sizes (Wyoming State Highway Department, undated), and one found no differences between performance under the two signing conditions (Snyder & Crossette, 1969).

The before/after approach used in this study differed in several important respects from the work of these investigators.

First, in the other studies, before and after periods were separated by varying intervals from a minimum of one day (Snyder & Crossette, 1969) to a maximum of seven months (Roberts, 1971). Two questions have been raised about the use of these intervals. One is that changes in the driver population might account for results obtained. A traditional measure (used in all but the Snyder & Crossette study) is the incidence of erratic or unusual maneuvers in the traffic stream at or near the gore area. It has been assumed that these maneuvers are indicative of route negotiation difficulty. If so, they are a function not only of the adequacy of the signing but also of the proportions of familiar and unfamiliar drivers in the sample of drivers under each of the signing conditions. The proportions of these two types of drivers will be influenced by the season (tourist traffic increases in summer in many locations) and probably by the day of the week (more people travel on Friday than Thursday). One correction procedure is to count the number of vehicles with local and nonlocal license plates in the samples under each signing condition. Such information was not obtained by these investigators, however.

The second question which can be raised in connection with studies with short time intervals between the before and after conditions is whether effects measured are due to novelty; that is, to the arousal properties of a sudden change in signing. Local drivers who have viewed the old signs many times before would be the group expected to exhibit this effect. Either an improvement or a deficit in performance could result depending upon the degree of arousal or attentional demand of the new signs and the interaction between such effects and the performance of the driving task. Such an effect, if present, would probably not be permanent nor would it be indicative of a true improvement or decrement in driver performance resulting from the change in route guidance signing.

To summarize then, in any field study of the relative effectiveness of various types of route guidance signing, the design must accommodate several factors. These are: the proportions of familiar and unfamiliar drivers under the conditions being evaluated; a possible novelty effect of the signing change on drivers familiar with the test sites; and, the fact that a large proportion of familiar drivers may mask any effects of the signs on unfamiliar drivers, particularly when measures other than erratic maneuvers are employed.

The study described here was designed with these considerations in mind. There were three study phases; Before, After, and Acclimation. Before and After measures at each site were separated by one year. This interval minimized traffic populational and seasonal differences. In addition, week day specificity was maintained with Before and After measurements made on the same day of the week, weather permitting.

The Acclimation phase permitted the investigation of short-term novelty effects. This phase was a mini-before/after study at the time of sign change. Data were collected on the day before sign change and on the day after sign change with followup data collection for up to six weeks.

To assist in interpretation of all phases, vehicles were classified as local (carrying Maryland, Virginia, or District of Columbia license plates) or nonlocal. Also, because drivers of different types of vehicles might react to the sign change differently, data collected were stratified by vehicle type.

Besides the above, the approach had three further features. The first was inclusion of a control interchange. Conventional signs were not replaced by diagrammatics at this interchange. Thus, any changes in the measures of vehicular behavior at this interchange under the Before and the After conditions could not be attributed to signing since this remained constant. Data at this interchange provided a baseline against which data collected at the test interchanges could be compared.

A second feature was that data were collected under the two signing conditions at numerous sites; specifically, on seven approaches to five interchanges. With the exception of one interchange which was signed only at the gore, the test interchanges contained advance, exit direction, and one or two gore signs. All major sign locations within the control interchange and within each test interchange were studied.

Finally, multiple measurement systems were used. These were questionnaires administered to motorists, time-lapse films for counting unusual maneuvers, and a unique data collection technique, the Traffic Evaluator System (TES). The TES permitted gathering data on a number of parameters such as speed, headway, volume, and lane maneuvering for all vehicles passing through a 1500-foot section of multi-lane highway.

CHAPTER III

METHODS

Test Sites

The study sites were on I-495 (Capital Beltway) and on a short segment of I-70S which intersects it. I-495 is a loop 66 miles in length surrounding the District of Columbia and passing through the States of Maryland and Virginia. The intersection of the Capital Beltway with Interstate Route 70S is in the northwest quadrant and effected by a major fork interchange. Four of the 38 existing interchanges on the Capital Beltway were studied, along with the first interchange on intersecting I-70S. The four Beltway interchanges are successive and are located in the northwest quadrant of the Capital Beltway. Figure 1 on the following page indicates the test sites. Specifically, proceeding clockwise around I-495, the interchanges are 15 North, 16 North, 17 North, and 18 East. (The cardinal directions indicate motorist direction of travel. Thus 15 North indicates that the motorist is proceeding north on I-495 and approaching Interchange 15.) In the counterclockwise direction, two of these interchanges were studied, 18 West and 16 South.

Interchange 17 is the point of junction between the Capital Beltway and Interstate Route 70S. Proceeding north on I-70S, the Democracy Boulevard interchange is encountered. This interchange was also a test site.

All interchanges are located in the State of Maryland. Interchange 15, the first in the sequence of interchanges studied in the clockwise direction, is encountered by the motorist immediately after crossing the Potomac River which separates Maryland and Virginia.

One of the interchanges, 18 West, was designated as the control interchange. Conventional signs were not replaced by diagrammatic signs at this interchange during the course of the study.

As has been mentioned, in the clockwise direction the test site interchanges follow each other sequentially. One of two different series of the new signs will be experienced by the motorist depending upon his route. If his route is via the Capital Beltway to Interstate Route 70S, he will encounter the guide signs at Interchanges 15, 16, 17, and Democracy Boulevard on I-70S. Alternately, if his route does not involve connecting with I-70S, he will pass through Interchanges 15, 16, 17, and 18.

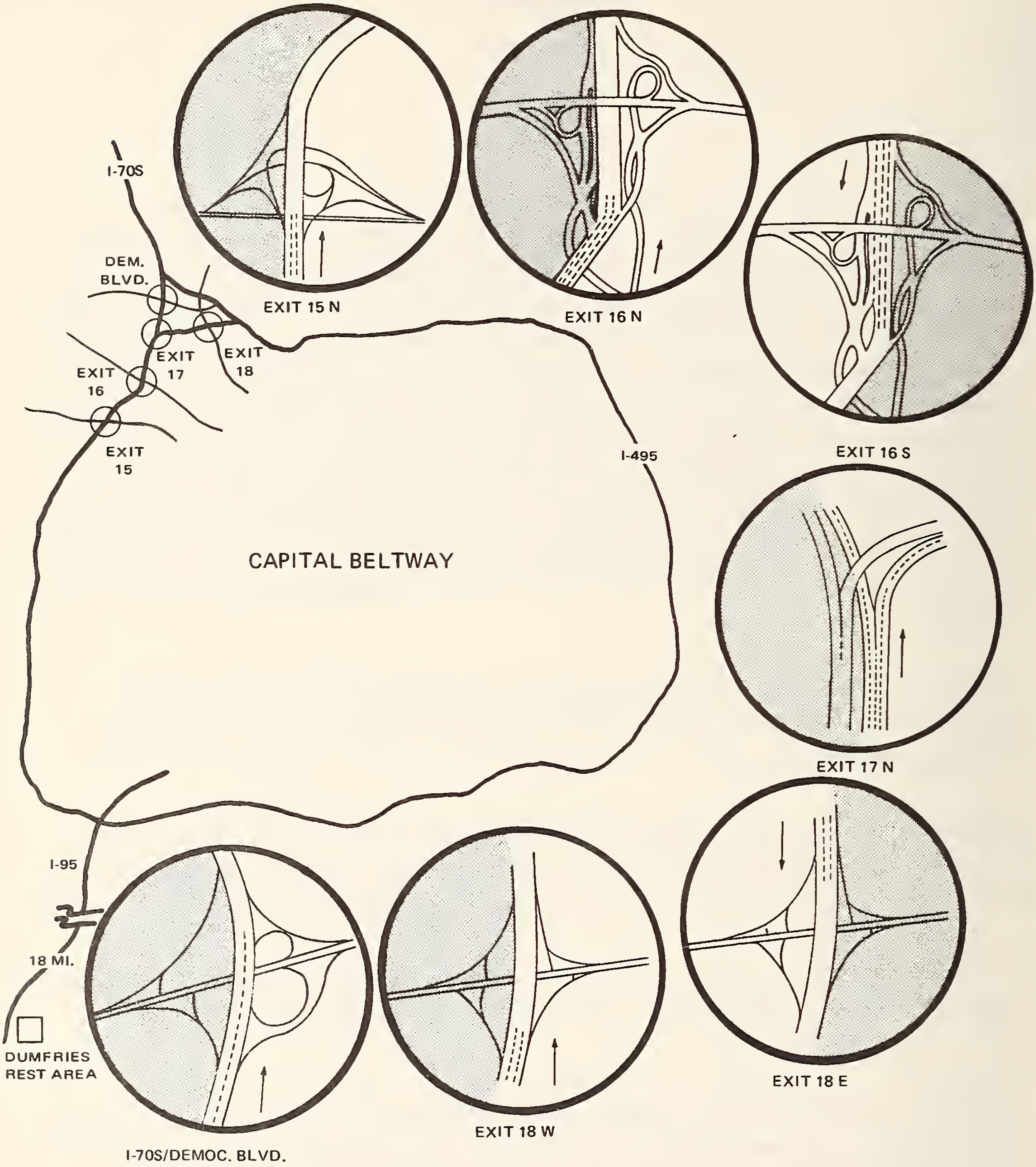


Figure 1. Location of study interchanges. White areas of inserts show each approach studied and the direction of traffic flow on that approach. (Through traffic lanes in the approach direction only are shown.) It will be noted that approaches vary from two to four lanes.

The interchanges themselves represent a variety of types and characteristics. These are described on the following pages and illustrated in the accompanying figure. Proceeding first in the clockwise direction:

Interchange 15 North

The approach to the exit ramp is across the Cabin John Bridge above the Potomac River. While traversing the bridge, the motorist crosses a state line, leaving Virginia and entering Maryland. There is no advance signing and no deceleration lane precedes the exit ramp. The sign at the gore directs the motorist onto a single lane exit ramp from which he may go either east or west on the George Washington Memorial Parkway.

Interchange 16 North

The northbound driver approaching this interchange encounters a tangential off ramp. Failure to make a positive steering action to follow the left-curving Beltway will result in exiting from it. On the ramp itself, the driver must choose between going east or west on River Road. The choice point occurs one-third mile after exiting onto the ramp. Thus, this interchange allows investigation not only of driver behavior at the gore of a tangential off ramp but also of behavior at close sequential choice points.

Interchange 17 North

This is a major fork interchange. Two of the four lanes continue to the left as Interstate Route 70S while the remaining two lanes curve to the right, continuing as I-495. In plan view, this interchange appears extremely simple. However, the northbound driver must contend with a left-hand exit and a reduction in the number of lanes on I-495.

Interchange 18 East

The driver who continues on I-495 at Interchange 17 next encounters a simple diamond interchange. A single ramp near the crest of a slight rise connects the exiting driver with Old Georgetown Road. The exit ramp is preceded by a deceleration lane of approximately 700 feet.

Democracy Boulevard

The Democracy Boulevard interchange occurs less than one mile after exiting onto Interstate Route 70S at Interchange 17. Democracy Boulevard is a partial cloverleaf interchange without a collector-distributor. The exiting driver may select one of two exit ramps, the first leading east on Democracy Boulevard; the second leading west. A deceleration lane of approximately 350 feet precedes the first exit. Drivers electing to exit at the second ramp must contend with traffic merging into I-70S from Democracy Boulevard.

The distance from Interchange 15 North to Democracy Boulevard or to Interchange 18 East on I-495 is about six miles.

In the counterclockwise direction, two interchanges were studied.

Interchange 18 West

This interchange was chosen as the control interchange. It is a simple diamond with a single off ramp and a deceleration lane of about 700 feet. Road curvature restricts sight distance so that the gore cannot be seen from either the advance or exit direction sign locations.

Interchange 16 South

This is a complex interchange with some cloverleaf characteristics. There are two exit ramps and a collector-distributor. Additional choice points occur in the collector-distributor. There is no deceleration lane at the first exit. At the second exit, a lane drop situation exists with the right lane continuing as the exit ramp and the number of through lanes reduced from four to three.

Guide Signing

With the exception of Interchange 15 North, each interchange is signed with an advance, exit direction and one or two gore signs depending upon the number of exit ramps. On the northbound approach to Interchange 15, only one sign is provided, a gore sign at the exit.

All of the advance, exit direction and gore signs for the test and control interchanges were studied. There were six advance signs, six exit direction signs and nine gore signs. (There are two exit ramps or gore areas at Democracy Boulevard and two at Interchange 16 South.)

In addition, the ramp sign encountered by the motorist after exiting at Interchange 16 North was studied. The total number of signing locations studied was thus twenty-two.

Pictures of the signing at each site during the Before and After phases are shown on the following pages. The pictures of each pair of conventional and diagrammatic signs were taken at the same distance to facilitate comparison.

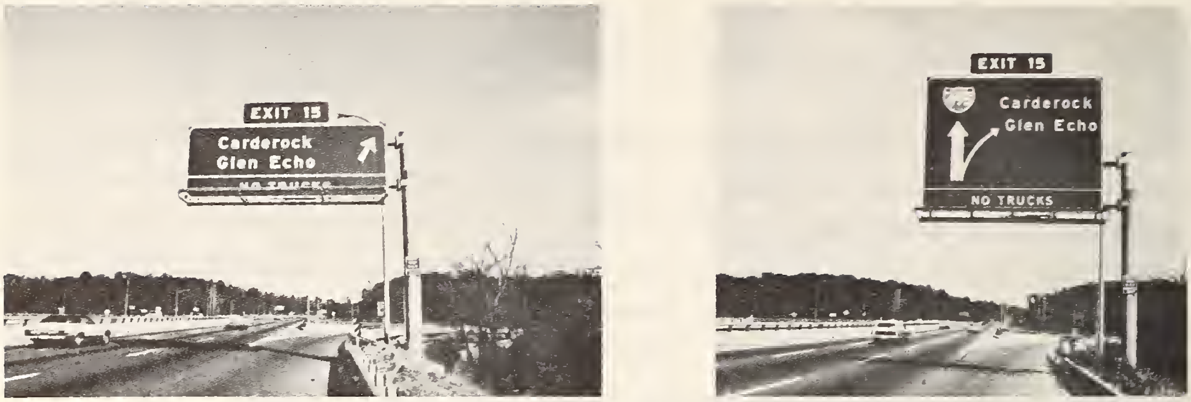
Table 1, following the pictures, shows the height of the lettering on the signs in inches and the height of the lettering for the word "EXIT" and for the exit number on the cap signs. Letter heights on the signs were 20/15 or 16/12 (upper case letters/lower case letters). It will be noted that letter sizes sometimes diverge from current standards. This is because the new edition (1971) of the *Manual on Uniform Traffic Control Devices* was published between the Before and After phases. The Before phase signs conformed to the older edition (1961) of the *Manual*. This meant that the new signs had to conform to the old edition also to avoid confounding the experimental results by varying the sight distance at which the signs could be read. However, it was desirable that the new signs could be made to conform to the new standards once data collection was complete. The problem was resolved by designing the new signs to meet the new standards but replacing the sign legend with the legend from the old signs where necessary for the duration of the experimental study. All the cap signs on the new signs were replaced by the old cap signs for the same reason. The legend and the cap signs prepared for the new signs will be mounted on the signs after the data collection period.

The problem in letter size constancy between the new and old signs was not noticed until the new signs were erected. This accounts for the fact that during the Acclimation phase the diagrammatic advance sign at 17 North and the diagrammatic exit direction sign at 16 South had legends which were larger than those on the equivalent conventional signs. This was corrected before the After study was undertaken.

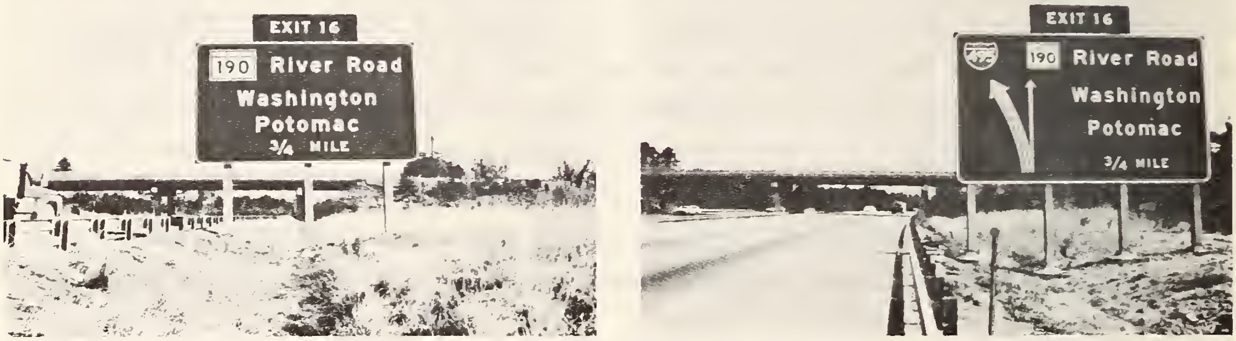
In one circumstance, the above method for achieving constancy between the two phases could not be applied. This was for interstate and state shields which had slightly different dimensions on the conventional and diagrammatic signs.

Review of Table 1 indicates that in overall size, the new signs were generally larger than the old, sometimes by a considerable amount. Increases in height (as opposed to width) necessary to accommodate the diagrammatic were the major cause of the overall increase in area.

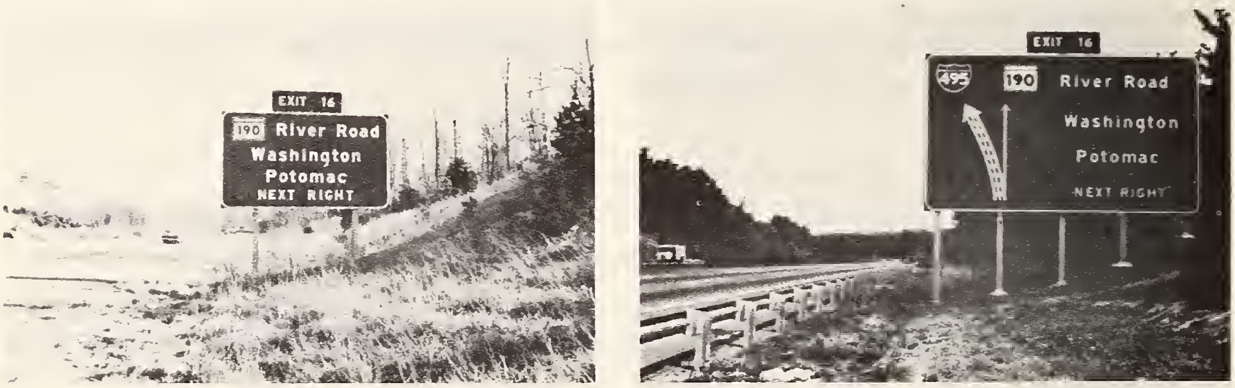
BEFORE AFTER



INTERCHANGE 15 GORE(EXIT) SIGN (No Advance Signs)



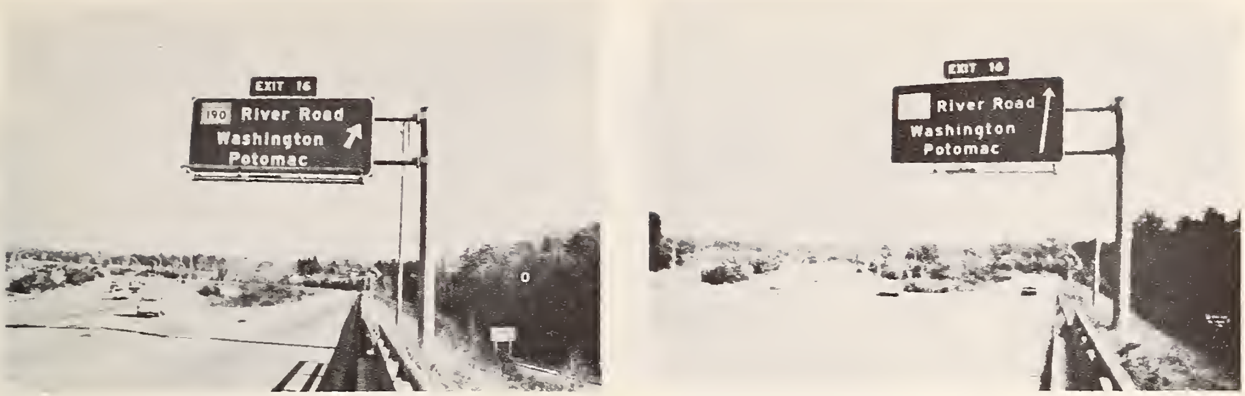
INTERCHANGE 16N ADVANCE SIGN (G-2 Location)



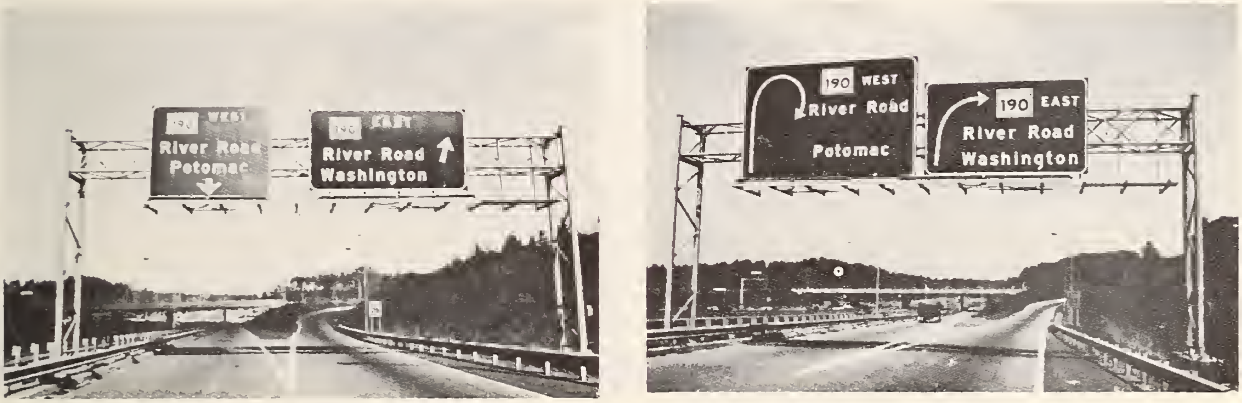
INTERCHANGE 16N EXIT DIRECTION SIGN (G-1 Location)

Figure 2. Before/After signs of Capital Beltway Interchanges 15, 16, 17, and 18 respectively, and the 70S/Democracy Boulevard Interchange.

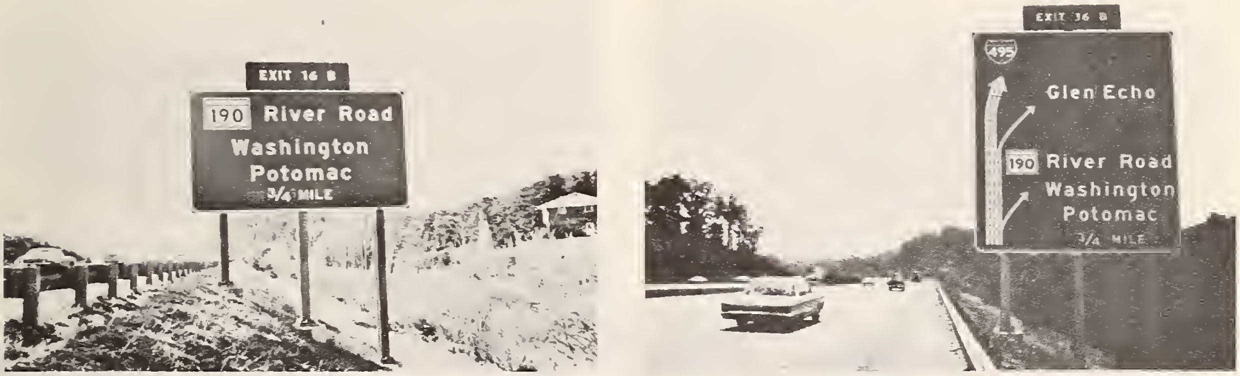
BEFORE AFTER



INTERCHANGE 16N GORE(EXIT) SIGN



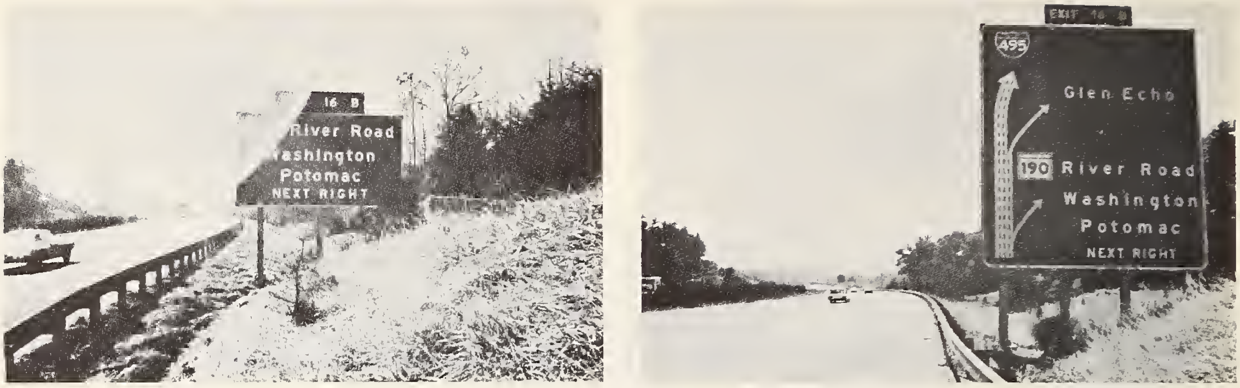
INTERCHANGE 16N EXIT RAMP SIGNS (Beyond Gore)



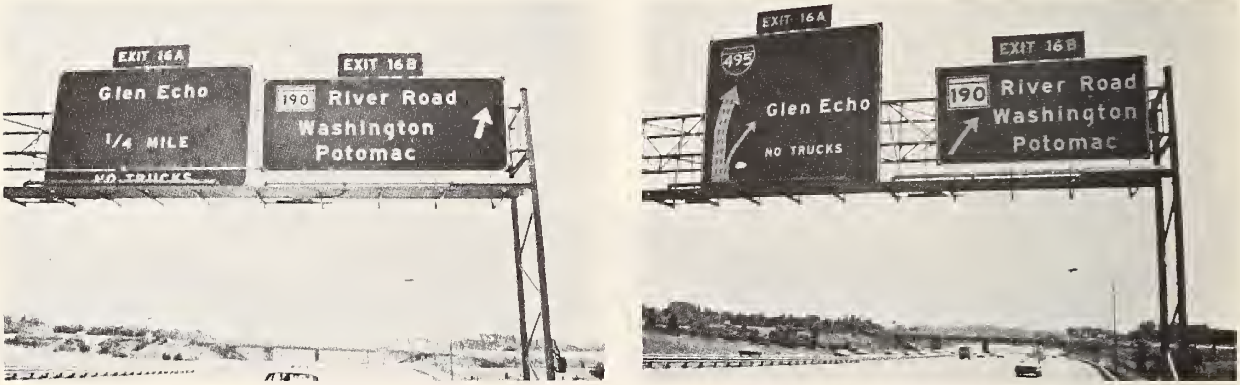
INTERCHANGE 16S ADVANCE SIGN (G-2 Location)

Figure 2 (Cont'd.). Before/After signs of Capital Beltway Interchanges 15, 16, 17, and 18 respectively, and the 70S/Democracy Boulevard Interchange.

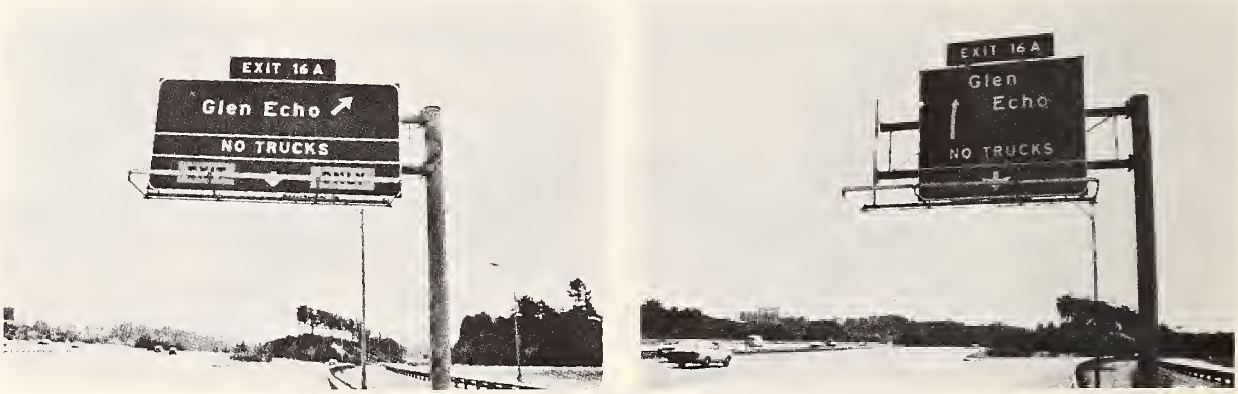
BEFORE AFTER



INTERCHANGE 16S EXIT DIRECTION SIGN (G-1 Location)



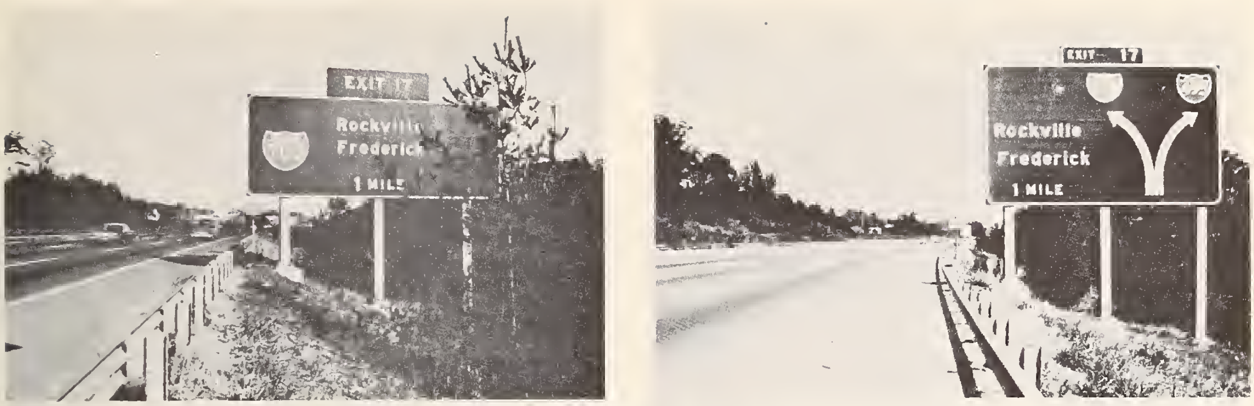
INTERCHANGE 16S GORE(EXIT) SIGN (First Gore) and
EXIT DIRECTION SIGN (Second Gore)



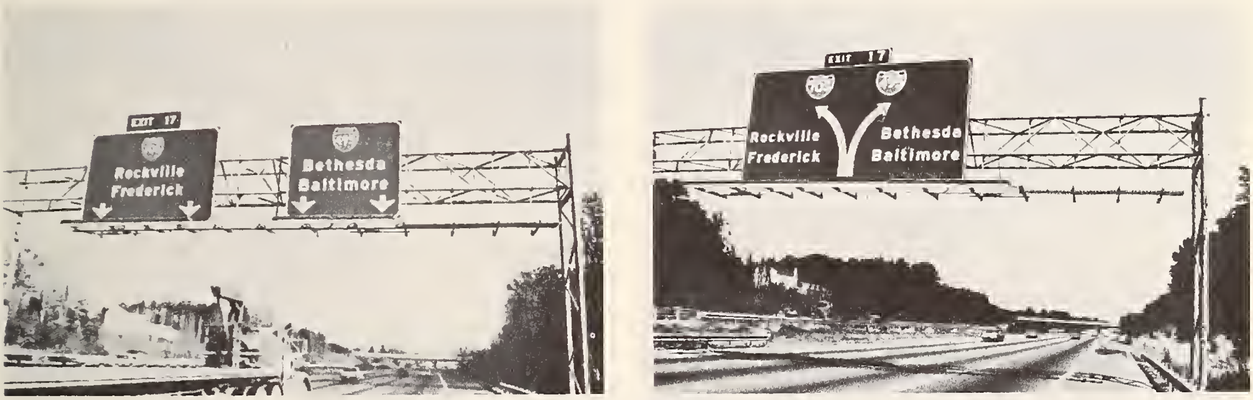
GORE(EXIT) SIGN (Second Gore)

Figure 2 (Cont'd.). Before/After signs of Capital Beltway Interchanges 15, 16, 17, and 18 respectively, and the 70S/Democracy Boulevard Interchange.

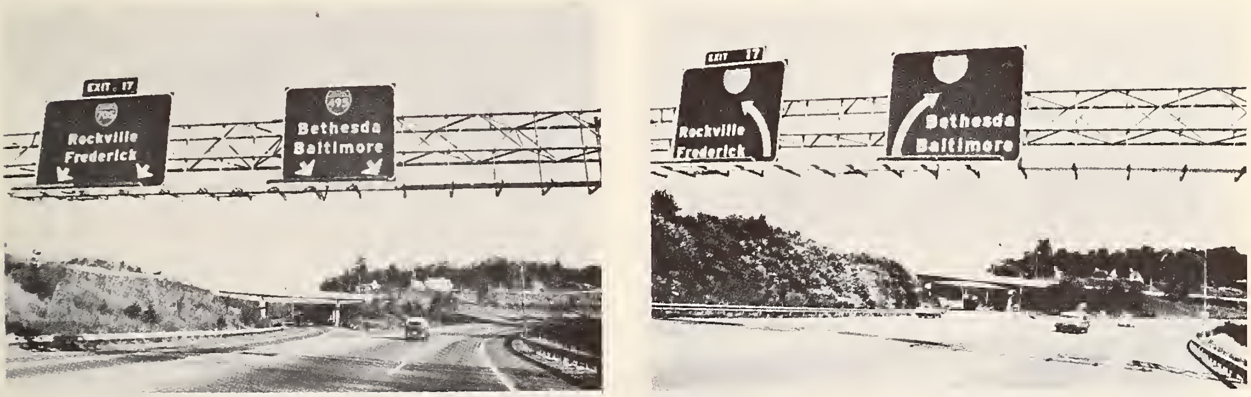
BEFORE AFTER



INTERCHANGE 17N ADVANCE SIGN (G-2 Location)



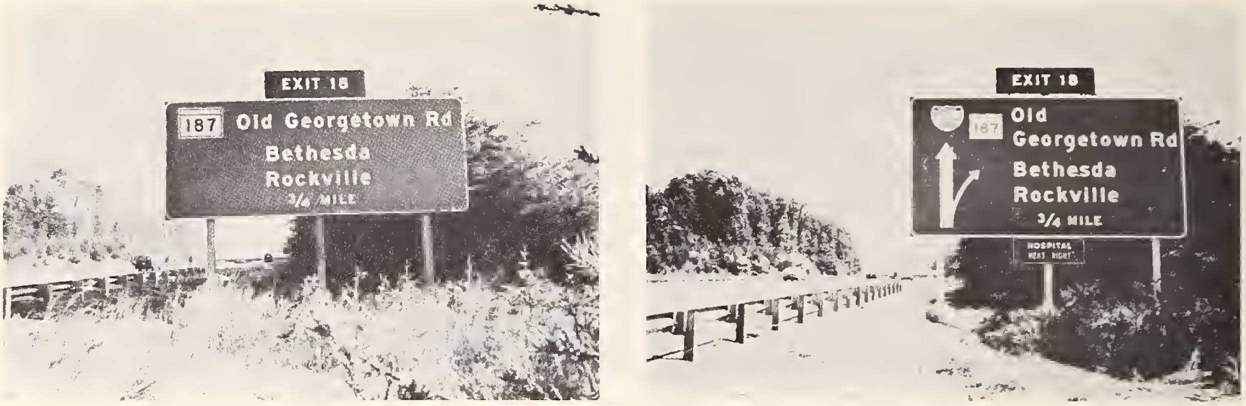
INTERCHANGE 17N EXIT DIRECTION SIGN (G-1 Location)



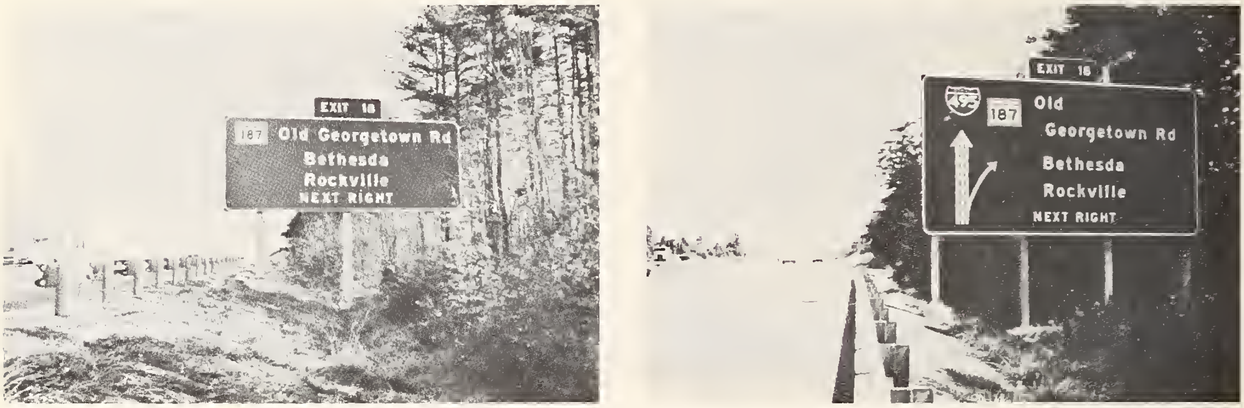
INTERCHANGE 17N GORE(EXIT) SIGN

Figure 2 (Cont'd.). Before/After signs of Capital Beltway Interchanges 15, 16, 17, and 18 respectively, and the 70S/Democracy Boulevard Interchange.

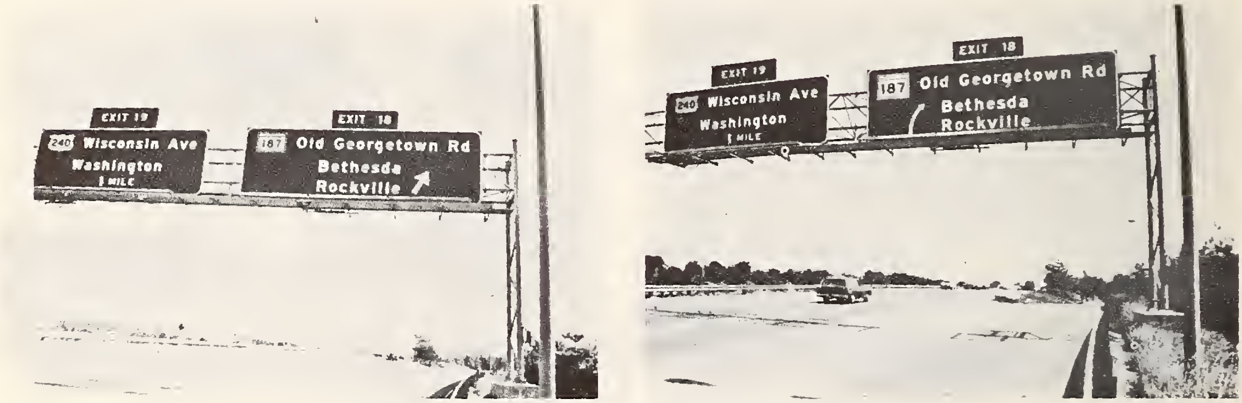
BEFORE AFTER



INTERCHANGE 18 E FIRST ADVANCE SIGN (G-2 Location)



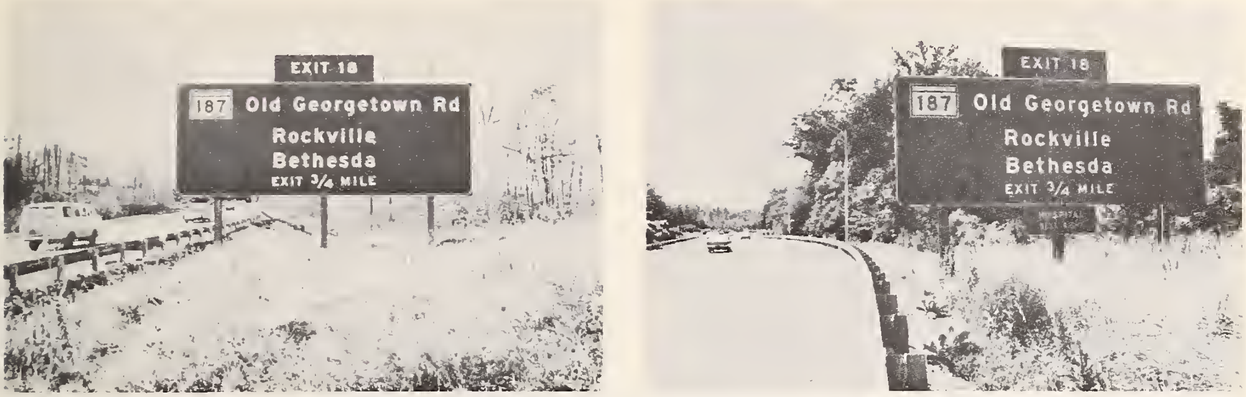
INTERCHANGE 18E EXIT DIRECTION SIGN (G-1 Location)



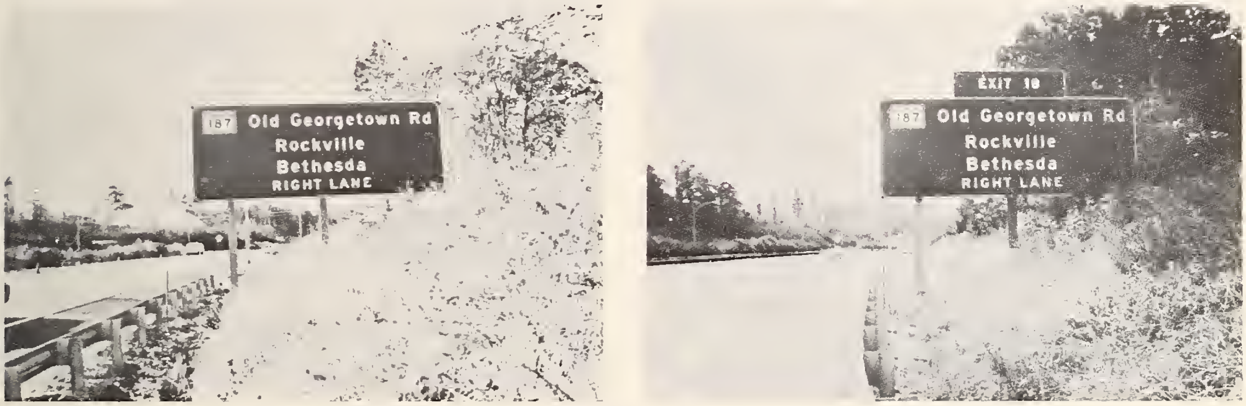
INTERCHANGE 18E GORE(EXIT) SIGN

Figure 2 (Cont'd.). Before/After signs of Capital Beltway Interchanges 15, 16, 17, and 18 respectively, and the 70S/Democracy Boulevard Interchange.

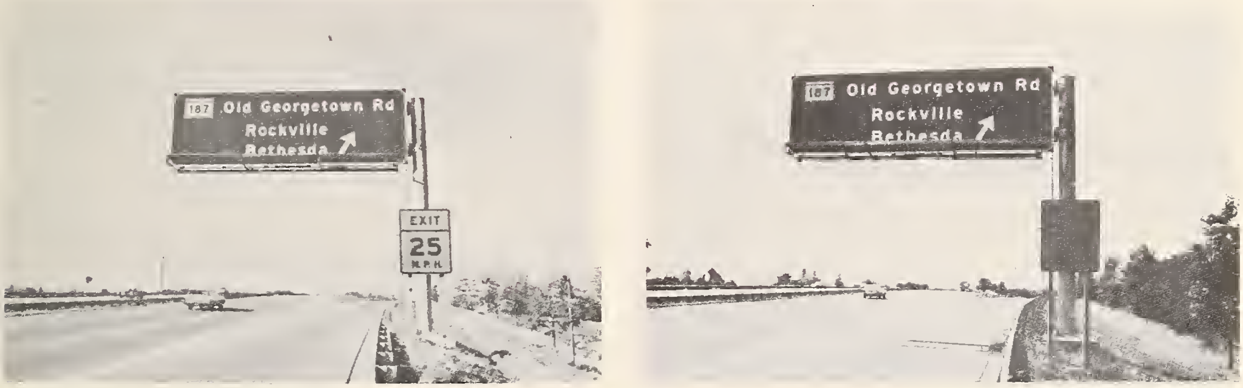
BEFORE AFTER



INTERCHANGE 18 W ADVANCE SIGN (G-2 Location)



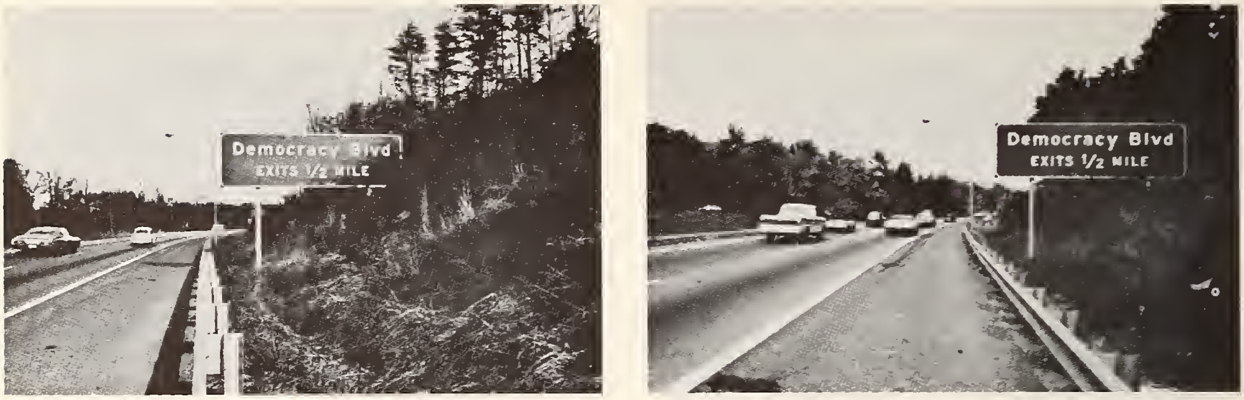
INTERCHANGE 18W EXIT DIRECTION SIGN (G-1 Location)



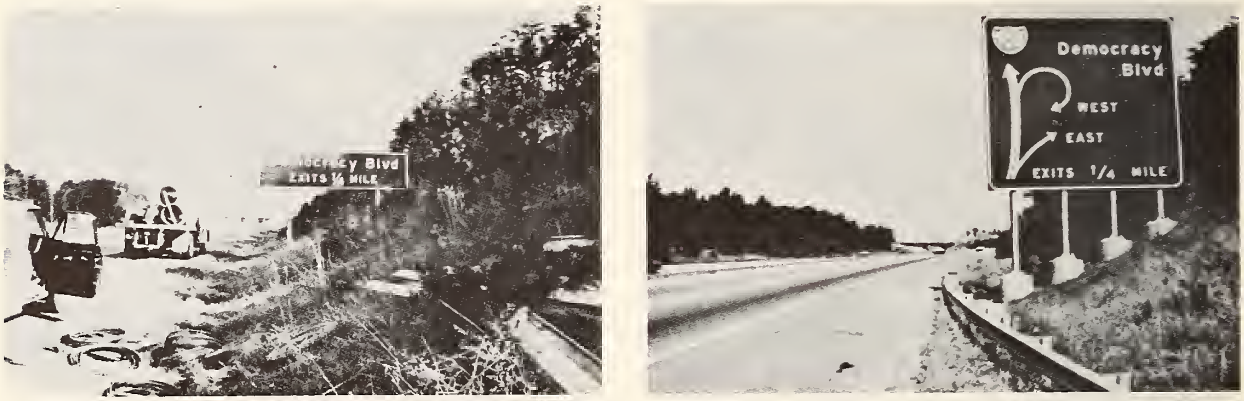
INTERCHANGE 18W GORE(EXIT) SIGN

Figure 2 (Cont'd.). Before/After signs of Capital Beltway Interchanges 15, 16, 17, and 18 respectively, and the 70S/Democracy Boulevard Interchange.

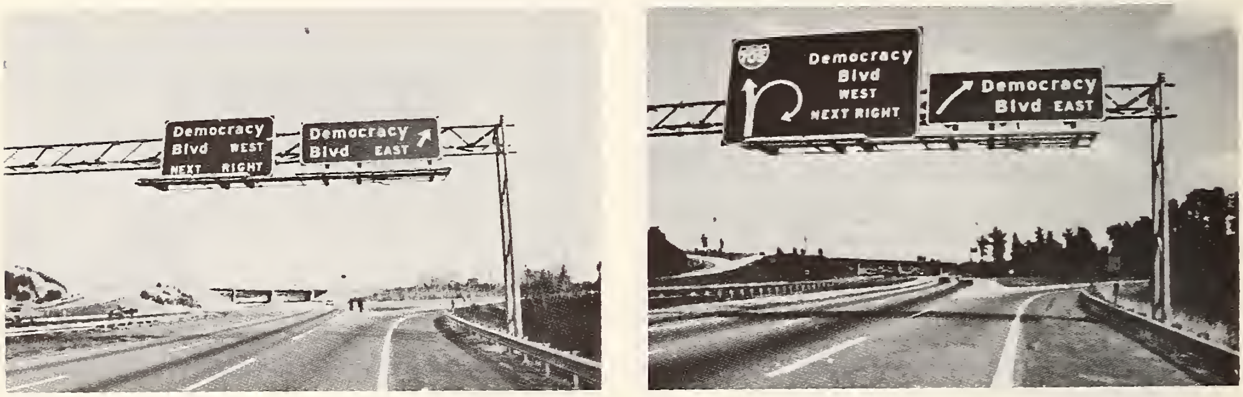
BEFORE AFTER



70S/DEMOCRACY BLVD ADVANCE SIGN (G-2 Location)



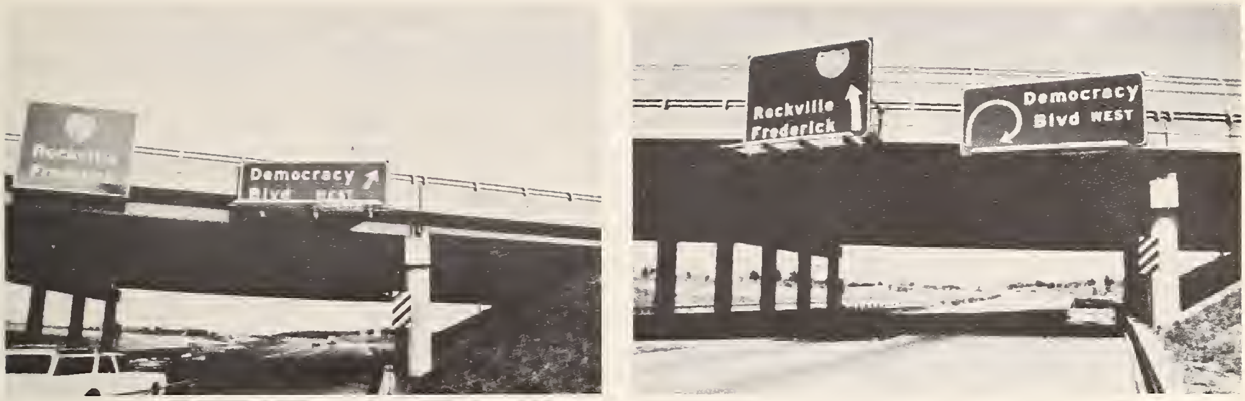
70S/DEMOCRACY BLVD EXIT DIRECTION SIGN (G-1 Location)


Democracy Blvd WEST NEXT RIGHT
Democracy Blvd EAST
Democracy Blvd WEST NEXT RIGHT
Democracy Blvd EAST

70S/DEMOCRACY BLVD GORE(EXIT)SIGN (First Gore) and
EXIT DIRECTION SIGN (Second Gore)

Figure 2 (Cont'd.). Before/After signs of Capital Beltway Interchanges 15, 16, 17, and 18 respectively, and the 70S/Democracy Boulevard Interchange.

BEFORE AFTER



70S/DEMOCRACY BLVD GORE(EXIT) SIGN (Second Exit)

Figure 2 (Cont'd.). Before/After signs of Capital Beltway Interchanges 15, 16, 17, and 18 respectively, and the 70S/Democracy Boulevard Interchange.

Table 1

Dimensions of Signs, Letter Heights and Heights of Cap Sign Legends Under the Conventional and Diagrammatic Signing Conditions

Interchange	Sign[1]	Type Mount[2]	Size (Feet)		Increase		Letter Height[3] Inches	Cap Sign[4]		
			Conv.	Diag.	Sq. Ft.	%		Exit	Number	
15 North	G	O	22 X 8½	20½ X 16	141	75	16/12	15	15	
16 North	A	S	24 X 13½	29 X 17	169	52	20/15	15	15	
	E–D	S	18½ X 10½	29 X 17	299	154	16/12	12	12	
	G	O	21 X 9	20 X 10	11	6	16/12	12	12	
	Ramp	O	14 X 11½	20½ X 14	126	78	16/12	None		
			18 X 9½	17 X 10	−1	−1				
16 South	A	S	24 X 13½	27 X 24	324	100	20/15	15	15	
	E–D	S	18½ X 10½	27 X 24	453.75	234	16/12	12	12	(*)
	G (W–P)	O	12½ X 19½	18 X 16	44.25	18	16/12	12	12	
			22 X 9	18 X 9	−36	−18		12	12	
	G (GE)	O	22 X 11	15 X 13	47	19	16/12	12	12	
17 North	A	S	28½ X 11	25 X 15	61.5	20	16/12	15	15	(*)
	E–D	O	18 X 12	28½ X 15	52	14	16/12	12	12	
			13 X 11½					None		
	G	O	18 X 12	15½ X 13	−14.5	−15	16/12	12	12	
			13 X 11½	15 X 13	45.5	30		None		
18 West	A	S	Not Changed				20/15	Not Changed		
	E–D	S	Not Changed				16/12	Not Changed		
	G	O	Not Changed				16/12	Not Changed		
18 East	A	S	34½ X 13½	32 X 17	78	16	20/15	15	15	
	E–D	S	27 X 10½	32 X 17	260.5	92	16/12	10	10	
	G	O	Arrow Only Replaced				16/12	12	12	
Democracy Boulevard	A	S	Not Changed				20/15	None		
	E–D	S	20 X 15	21 X 9	299	300	16/12	None		
	G–East	O	14 X 8	22 X 13	174	155	16/12	None		
			16½ X 5½	18 X 6	17.25	19		None		
	G–West	O	13 X 11	15 X 11	22	15	16/12	None		
			16½ X 5½	19 X 8	61.25	67		None		

---

[1] Abbreviations in this column indicate the three types of signs studied. These are G = gore, ED = exit direction and A = advance. There are two gores at Democracy Boulevard; East, which is first encountered by northbound motorists, and West, which is encountered next. There are two gores at 16 southbound; the Washington–Potomac (W–P) exit encountered first by southbound motorists, and the Glen Echo (GE) exit which is encountered next.

[2] O = overhead mounted sign. S = shoulder mounted sign.

[3] This is the height of the legend on the sign. 20/15 = 20 inches upper case, 15 inches lower case letters. 16/12 = 16 inches upper case, 12 inches lower case letters. The same size letters were used on conventional and diagrammatic signs — see text.

[4] The heights of the letters spelling the word EXIT and of the numbers of each exit are given in inches. The same cap signs were used for both diagrammatic and conventional signs—see text.

*Acclimation phase letter height 20/15.

Measurement Systems

Three techniques were used to evaluate traffic and motorist behavior as a function of conventional and diagrammatic signing conditions. These were the Traffic Evaluator System, time-lapse photography and questionnaires distributed to motorists.

Traffic Evaluator System

Development of the Traffic Evaluator System (TES) was begun in 1969 by the Federal Highway Administration to allow large-scale collection of data pertaining to the operating characteristics of highway traffic. The system records discrete events on magnetic tape. It is a rugged, portable, battery-operated system which can continuously monitor 60 switch contacts. Upon activation of any contact, the time of initial closure and the address of the active switch is written on seven-track computer tape.

The complete Traffic Evaluator System consists of an array of vehicle sensors, manual code boxes, power supplies, cables, and the evaluator recorder and electronics unit (sometimes referred to as the "evaluator").

Vehicle Sensors. Sensing of vehicles was accomplished with tapeswitches manufactured by Tapeswitch Corporation of America. The tapeswitch sensor consists of two metal strips separated by plastic spacers and enclosed in an extruded plastic jacket. When the wheel of a vehicle rolls onto the switch at any point along its length, the metal strips are pressed together and complete an electrical circuit. The length of each switch approximates the width of one lane of highway. Leadwires attached to the switches cross the road and end at the terminal boxes. Sensors were attached to the road with adhesive tape. Generally, two types of tape were used. Permacel P-50 is a white, double-face tape used between the switch and the road. Permacel P-676 is a 6-inch wide, silver-gray, waterproof, single-face, duct tape. It was placed over both switches and leadwires.

Manual Code Inputs. Associated with the Traffic Evaluator System is provision for manual code inputs. These may be defined in any way desired. Manual code inputs are made by pressing push buttons on "code boxes" connected to the roadside recorder. The boxes are small hand-held devices with an eight pushbutton keyboard. Data generated by pressing a push button are "written" on magnetic tape exactly like the tapeswitch sensor data. The codes so entered can be identified with a specific vehicle passing through the tapeswitch array.

Power Supplies. The evaluator system is designed to operate on three voltage sources, a 12-volt automobile storage battery for the road sensors and recorder, a 6-volt storage battery for the electronics unit, and a 12-volt dry cell for negative bias of the level converters. The recorder draws 40 watts when writing data and virtually no power in the standby mode. Two ampere-hours is the approximate current drawn depending on the characteristics of the vehicle array and traffic volume. The electronics package draws a steady 25 watts from the 6-volt battery. The drain on the bias supply is negligible.

Cables. The system is connected by 60 interchangeable cables. These are each 330 feet long, about 1/2 inch in diameter, and may be hooked together like household extension cords to obtain the necessary length. Amphenol connectors join the cables to the evaluator on one end and to either a manual code box or road switch terminal box on the other. Cable length is such that the evaluator and observers operating the manual keyboards can be located off the highway in concealed or inconspicuous locations.

Evaluator (Data Recorder). The evaluator consists of an electronics unit which codes incoming data, and a digital tape recorder for data storage. A pair of shielded wires are run from each switch in the array of vehicle sensors to a central position where they are connected to the evaluator. These are seen by the evaluator as normally open switches. The closing of a switch charges a capacitor which is sensed by a level converter and the resulting pulse is converted to a +5-volt logic level. After inversion, the pulse is routed through a diode matrix and encoded to six binary bits. The output is applied to the first stage of a six-word silo (first-in, first-out) memory. The appearance of a coded switch closure at the memory triggers a common cutoff line and is gated with the original pulse from the switch to fire a multivibrator which disables the active input until the vehicle has passed the sensor. A 10 kHz clock is the primary time-of-day mechanism. Twelve bits of time data are loaded into the silo memory with the switch closure code, and the resulting 18-bit word is read out of memory in its turn to the recorder. Manual code inputs are handled in similar fashion.

The clock is reset every 2016 milliseconds. This event is transmitted through the diode matrix just like a road switch and is recorded, giving a continuous record of time since initial device activation accurate to 500 microseconds.

In operation, the system continuously records switch or manual code identifications from up to 60 external inputs and the exact time each event occurred. The storage device is a Precision Instruments PI-1387 incremental digital tape recorder. Passive until commanded to record, this instrument writes six bits of data plus parity at each step. The three steps required to write the 18 bits of data generated by each switch closure is 15 milliseconds. The maximum writing speed at 200 characters per inch is 200 steps per second. A six-hundred-foot tape is used, representing a maximum capacity per reel of 480,000 switch closures (axles) or about 14,500 total vehicles distributed across three lanes each instrumented with a typical 12-switch array.

Certain limitations should be noted. The 500 microsecond uncertainty caused by the clock rate corresponds to about ±0.55 mph for a 55-mph vehicle if speed is measured using two switches separated by four feet. The subject vehicle may be making a small angle to the lane center line. A five-degree angle can cause an error at the four-foot speed trap of 0.21 mph. Placement of the switches is critical. A 1/4-inch error causes a ±0.29 mph reading. Other factors such as axle alignment on the subject vehicle, unevenly worn tires, etc. can have a small influence on the measures taken. Increasing the separation between trap pair members beyond four feet reduces some of the error sources but may increase placement error and makes the trap more sensitive to error caused by the acceleration of the subject vehicle. Averaging the speed of all axles is the obvious means for error reduction.

The evaluator in its present configuration contains only a six-word memory. Up to 10 microseconds are required to process data for each switch closure. The hardware may fail to recognize a second closure within the processing period of the first. If six switch closures are queued for the recorder, data generated will not be stored until there is room in the memory. The data written on the tape must be formatted into records and files for further processing. During the 0.75 seconds required to write an end of record code on the tape, no data can be recorded.

Computer processing of the data gathered in the field yields the following for each vehicle passing through the array:

- number of axles
- wheelbase
- lane changes
- straddles (i.e., vehicles between two lanes)
- velocity
- relative speed
- space headway

- time headway
- space tailway
- time of day.

These measures are each generated at a number of points along the highway, the number of points depending on the positioning of the tapeswitch traps.

Figure 3 on the following page illustrates the Traffic Evaluator System in operation in the field. Further information on the Traffic Evaluator System is provided in Appendix A.

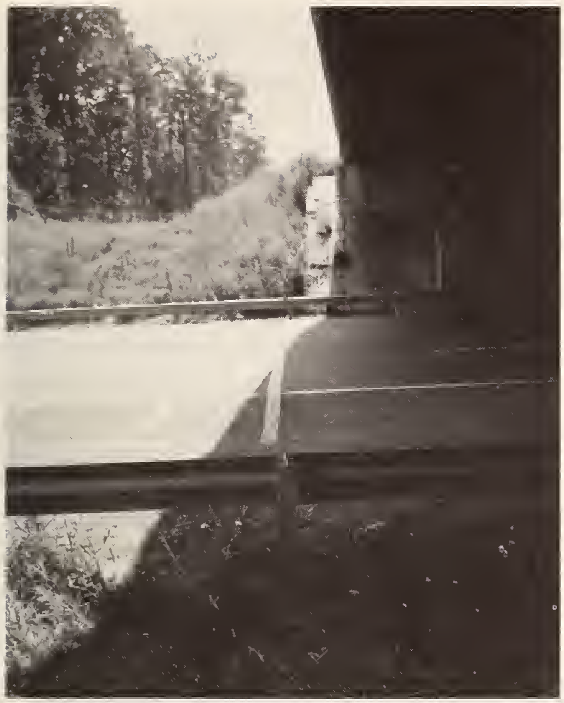
Time-Lapse Photography

Time-lapse films were obtained with the Minolta "Autopak-8 D10" Super-8 camera. An exposure rate of two frames per second was used resulting in 30 minutes of continuous data collection per roll of film. Both Kodachrome II and Ektachrome EF film were used, with the majority of filming done with Kodachrome II. The Kodachrome is more fine grained than the Ektachrome. However, the faster speed of the Ektachrome makes it useful under the low lighting of overcast days.

The most critical issue in using time-lapse photography for study of traffic behavior is selection of the field of view. This is a function of the focal length of the lens (continuously variable from 7 to 70 mm) and the camera location. The most desirable location is on an elevation, with the camera centered at the midline of the field of interest. Overpasses crossing about 800 feet upstream from the beginning of the area to be filmed are ideal. Such sites place the camera to the rear and above vehicles being filmed thus maximizing inconspicuousness and facilitating access by the operator while providing the most favorable field of view. Where ideal conditions were not available, the cameras were positioned in trees, on lamp poles, or in the shoulder or median on tripods. Figure 4 illustrates some of the camera locations used in the study. Cameras in locations obviously visible from the main roadway were camouflaged with weeds or by locating them near trees.

Questionnaire/Interviews

The Traffic Evaluator System and time-lapse films were used to measure physical characteristics of traffic operations such as speed and lane movements. The questionnaires distributed to motorists provided information on driver characteristics and attitudes. There were two classes of respondents: exit and thruput.



(a) Tapeswitches on the Beltway

(b) The Recorder-Electronics Package

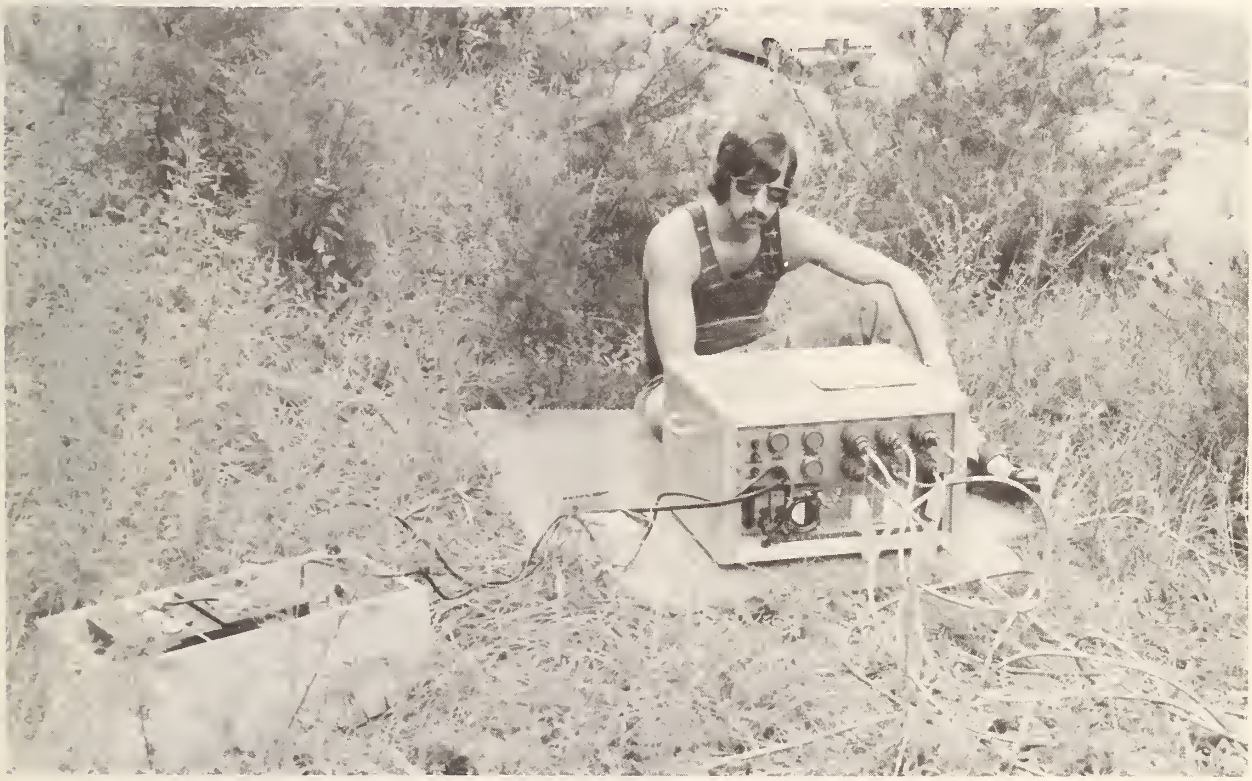
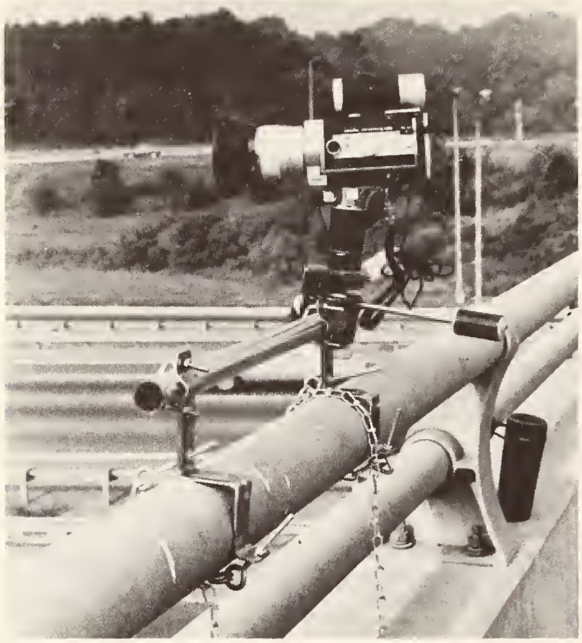
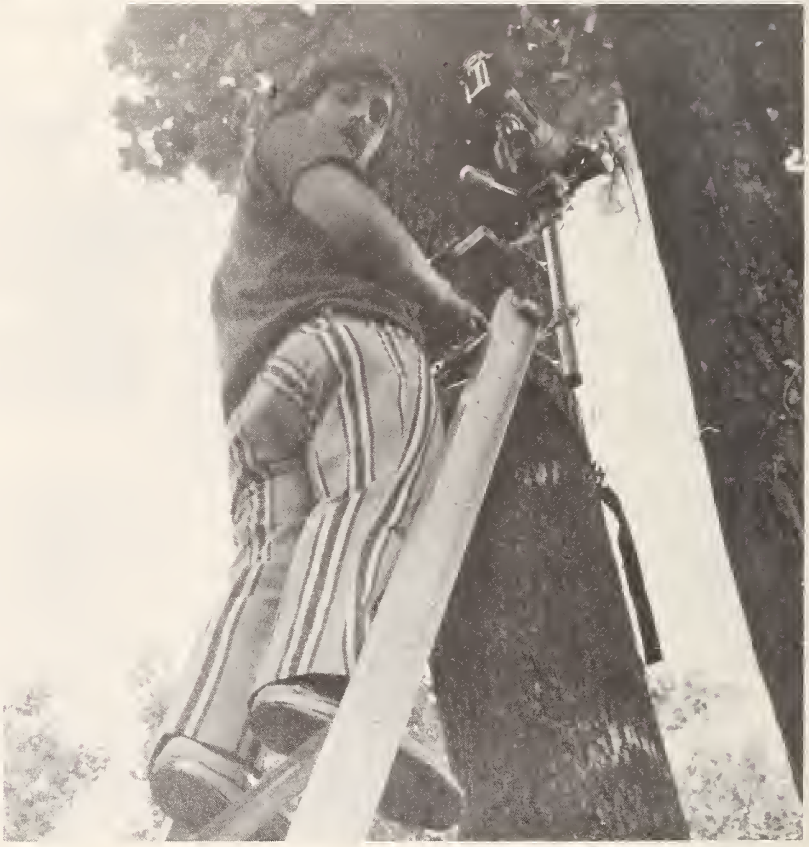


Figure 3. The Traffic Evaluator.



(a) Overpass Rail Mount



(b) Tree Mount

Figure 4. Cameras mounted for data collection.

Exit Respondents. These were drivers who left I-495 or I-70S at one of the exits under study. Exiting drivers were flagged over by a Maryland State Trooper at appropriate sites just beyond the exit. BioTechnology, Inc. personnel then administered the questionnaires.

Thruput Respondents. These were drivers who were generally en route to distant destinations. The drivers were approached before they reached I-495. BioTechnology personnel were stationed at Dumfries Rest area on I-95 approximately 12 miles south of the junction of I-95 northbound and I-495. Those drivers who planned to travel over the segments of highway under investigation were asked if they would cooperate in a traffic study by exiting at one of the interchanges on their route to complete a questionnaire. For travelers northbound on I-70S, the exit point was Democracy Boulevard eastbound and the interview was held in the Bethesda Congregational Church parking lot. For travelers eastbound and traveling clockwise on I-495, the exit point was Interchange 18 and the interview was conducted in the Bethesda-Chevy Chase YMCA parking lot. Those who agreed to cooperate were given a map and a ticket. The ticket entitled them to $5 on completion of the questionnaire. The motorists were not told the purpose of the study.

Standard questionnaires (OMB approval number 04-R-2435) were given to the motorists. The questionnaires were designed to elicit the signing information used and/or desired for route guidance, degree of route familiarity, correctness or incorrectness of exit selection and various items of demographic information. The questionnaire forms are included in Appendix B.

CHAPTER IV

DATA COLLECTION AND REDUCTION

Data Collection in the Before/After Study

General

The basic design of the Before/After study was parallel data collection efforts in each of the Before and After phases with one-year separation between phases. For example, data were collected with the Traffic Evaluator System (TES) at the gore of Interchange 17 northbound on Wednesday, 25 August in the Before phase. Data were also collected with the TES at the same site in 1972 on Wednesday, 23 August. The one-year separation minimizes seasonal influences, both environmental and due to driver populational characteristics, which might obscure the main effects attributable to signing changes. It will be noted that the one-year separation is weekday specific (i.e., Wednesday to Wednesday) rather than calendar date specific. The population of drivers varies across some days (e.g., Sunday compared to Monday). Before/after parallelism in terms of weekdays rather than exact calendar date reduces this effect. Because 1972 was a leap year, calendar dates in the After study lag those in the Before study by two days rather than one.

The data collection interval in each phase was of eight weeks duration, consecutively insofar as weather allowed. Characteristics of data collection with each of the three measurement systems; the TES, time-lapse photography, and motorist questionnaires are described below.

Traffic Evaluator System. The TES was deployed for seven weeks of the eight week data collection interval. Two sites were instrumented per week, and thus, evaluator system data were collected at 14 of the 22 signing locations. Data were collected continuously from 0930 to 1430; on Monday and Tuesday for one site and on Wednesday and Thursday for the other site each week. The 0930 to 1430 data collection period was selected deliberately to exclude rush hour traffic. The capabilities of the Traffic Evaluator System can be exceeded at the very low speeds and high volumes which sometimes occur in this period.

Manual code inputs were made Tuesday at the first weekly site and Wednesday at the second. One person was assigned to code each lane. Each person used an eight push button manual code box. Although a given vehicle could have been coded with more than one key, this possibility was found impractical when vehicles arrived in platoons. Coders must code the vehicle before it crosses the first of a designated tapeswitch pair, but after the vehicle ahead has crossed the pair. Lead time is limited primarily by headway distance of platooning vehicle members and secondarily by the frequently awkward locations for coders. Locations must provide camouflage yet also provide a view of both the vehicles to be coded and the tapeswitches. Accordingly, each vehicle was coded with one key according to the following illustration. Coders were instructed to keep the nonlocal vehicle category as valid as possible. Vehicles with nonlocal license plates accounted for roughly ten percent of all vehicles. (It should be noted that the terms nonlocal and foreign are used interchangeably for vehicles with plates other than Maryland, Virginia, the District of Columbia, or the U.S. Government.)

LOCAL 1 CAR	NONLOCAL (FOREIGN) 2 CAR	MOTORCYCLE 3 NO LICENSE
LOCAL SMALL 4 TRUCK	NONLOCAL (FOREIGN) SMALL 5 TRUCK	LICENSE PLATE 6 OBSCURED
LOCAL LARGE 7 TRUCK	NONLOCAL (FOREIGN) LARGE 8 TRUCK	INOPERATIVE 9
INOPERATIVE 0		INOPERATIVE 0

NOTES:

Local: Maryland, Virginia, District of Columbia license plates. Also U.S. Government plates.

Nonlocal: any other license plate. If a vehicle has several license plates, code as nonlocal only if all plates are nonlocal. The terms nonlocal and foreign are used interchangeably.

Car: all types of automobile from ambulance to station wagons to small foreign sports cars. Also in this category are any such vehicle towing small two-wheeled devices (such as small U-Hauls or single-axled boat trailers).

Small truck: pickups, microbuses, panel trucks, step vans, and pickup trucks with mounted campers. Vehicles in this category have two axles and the cab is integrated with the body. Almost all have four tires. However, if extra tires are added (as sometimes occurs on the rear axle), all tires are small rather than the larger tires found on large trucks.

Large truck: tractor trailers, large vans, buses, and cars towing mobile homes. The cab is generally separate and connected by a linkage. There are generally more than two axles and more than four tires. Tires are generally large.

Key 3: always used for motorcycles. Also used for vehicles lacking license plates. Most of these are nonlocal vehicles. Twelve states (which do not include the "local" states, Maryland, Virginia, and the District of Columbia) do not issue an anterior plate, only a rear plate.

Key 6: used when the license plate is so obscured with dirt that the state of origin cannot be identified. This key is also used when the coder's view of the license plate is obscured by another vehicle.

The schedule for coding was a half hour of coding followed by a 15 minute break. This half-hour-on 15-minutes-off schedule was followed continuously from 0930 to the end of the Traffic Evaluator System data collection interval at 1430. It will be noted that manual coding by this schedule is synchronized with the camera filming schedules described in the next paragraph.

Time-Lapse Photography. Time-lapse films were made at all 22 sites. During the Before phase, at the 14 sites also studied with the Traffic Evaluator System, two sets of time-lapse films were taken. One set was taken one week prior to data collection with the evaluator. The other set was taken while data were being collected with the TES. The purpose was to see whether the TES itself had a measurable effect on traffic behavior. During the After phase, films were made concurrent with the use of the TES only.

On each filming day, four one-half hour films were made according to the following schedule:

0930–1000	1230–1300
1100–1130	1400–1430

Films made at TES sites were taken on Tuesday or Wednesday (the manual coding days) while films at the eight sites where the TES was not used were taken on Thursday.

The locations of the Traffic Evaluator System data recorder and of the manual coders were carefully selected to provide coverage so that people and instruments were inconspicuous to motorists. Cameras were camouflaged with brush or located behind trees at roadside locations. Personnel wore dark clothing.

Questionnaires. With two exceptions, exiting motorists were stopped on one off ramp of each interchange. No questionnaires were administered at Interchange 15 because a suitable point to flag vehicles over without hazard could not be found. At the Democracy Boulevard Interchange, a cloverleaf, motorists exiting at both the east and west ramps completed the questionnaire.

The exiting motorist questionnaires were administered on Thursdays. In general, questionnaire data was collected at two interchanges per day—one in the morning and one in the afternoon.[1] The questionnaires were administered by a team of two or three people. One person worked a car at a time. After a brief introductory statement (see Appendix B), the questionnaire administrator asked the motorist if he would complete the questionnaire. Motorists completed questionnaires in their cars, and the questionnaire administrator remained nearby in case the respondent had any questions. Four items of information were entered on a separate sheet by the questionnaire administrator. These were time, exit location, state in which the license plate was issued, and sex. (The license plate was entered separately because the relationship between the license plate and place of residence was of interest. Both the place of residence and length of residence were filled in by the respondent. It was felt that answers might be less than complete if the respondent were also asked to write down the state in which license plate was issued. This was because of laws limiting the period of time allowed between changes in residence and obtaining new license plates.) This separate sheet was then stapled to the questionnaire.

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[1] We are indebted to the Maryland State Police for their assistance in flagging motorists down for interview.

A demand sampling procedure was used. Motorists were flagged off by a State Trooper at the Trooper's discretion but so as to keep each of the two or three member interview team occupied with a vehicle. The Troopers were asked not to select vehicles and were told that as random a sample as possible with regard to vehicle type, license plate, etc. was desired.

After questionnaires had been obtained from motorists at all scheduled sites, three additional sets of questionnaires were obtained from motorists exiting at Interchanges 16 northbound, 17 northbound, and 18 westbound and eastbound. This was done because review of the data indicated that the percent of drivers completely unfamiliar with the road and/or with nonlocal license plates (other than D.C., Maryland, or Virginia) was small. Thus, additional data were gathered by selecting vehicles. At Interchanges 16, and 18, only vehicles with nonlocal plates were flagged down. The standard exit case questionnaire was administered to drivers of these vehicles. At Interchange 17, vehicles with nonlocal plates were flagged down and the drivers were asked if they had driven the route less than five times. Only those drivers who met this constraint were asked to complete the standard questionnaire.

It will be remembered from the discussion under Measurement Systems in Chapter III, that questionnaires were also completed by a second class of respondents designated as thruputs. Such respondents were motorists stopping at Dumfries Rest Area on I-95, south of the Capital Beltway whose route of travel took them through the test section and who agreed to participate in the study. The thruput respondents were obtained on Fridays using a team of four. Two were stationed at Dumfires Rest Area to identify motorists willing to participate. One was stationed at the Bethesda Congregational Church just off the Democracy Boulevard interchange for motorists whose route took them up I-70S. The fourth team member was stationed at the Bethesda-Chevy Chase YMCA just off Interchange 18 for motorists whose route took them around the Capital Beltway beyond the test sites. The motorists completed the questionnaires at the Church or YMCA as appropriate.

Study Sites By Measurement System and Calendar Date

Table 2 on the following page summarizes the 22 study sites and the measurement systems used at each during the Before and After phase data collection efforts. Data collection activities were identical in the two phases except that in the After phase, time-lapse films at TES sites were made only concurrently with use of the TES system. Thus no "Pre-Eval" films (see the table) were made in the After study. In this table, study sites are designated by interchange and sign. Abbreviations used in the table and elsewhere in this report for route guidance signs are as follows:[1]

- G-2: the advance sign. The first sign encountered by motorists approaching the interchanges in the test section. These signs are located one-half to one mile from the gore.
- G-1: the exit direction sign. The second sign seen by the motorists approaching the interchange. These signs are located one-fourth to one-half mile from the gore.
- G: the sign at the exit or gore.

Table 3 summarizes the data collection efforts in the Before phase in relation to calendar date. Reference to the table indicates that the Before phase data collection effort was divided by Labor Day which occurred on 6 September 1971. Three weeks of data were collected before Labor Day, the remaining five weeks after Labor Day. The division is important because the Labor Day weekend marks the end of summer for many people. Tourist travel may be expected to decrease after Labor Day.

Table 4 summarizes data collection efforts in the After phase in relation to calendar date. Labor Day occurred on 4 September 1972. As in the Before phase, three weeks of data were collected before Labor Day, the remaining five weeks after Labor Day.

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[1] The possibility for confusion of these designations with those used by A.M. Voorhees (1966) should be noted by the reader. In the Voorhees study, the gore sign was designated G-1. The sign we have designated G-1 becomes G-2 in their system, and the sign we have designated G-2 becomes G-3 in their system.

Traffic Evaluator System Tapeswitch Deployment

The Traffic Evaluator System provides point source data or a profile of traffic operations at selected points, the points determined by the location of the tapeswitches. Because data are collected only at tapeswitch locations, the positioning of the tapeswitches is important and will determine the kind of traffic profiles obtained.

Table 2

Overview of Data Collection Activities in the Before/After Study

Interchange	Sign	Traffic Evaluator	Time-Lapse Films[1]			Questionnaire[2]
			Pre-Eval.	With-Eval.	Non-Eval.	
15 N	G	X	X	X		
16 N	G–2				X	
	G–1	X	X	X		
	G	X	X	X		X
	Ramp				X	
16 S	G–2				X	
	G–1				X	
	G (W–P)[3]	X	X	X		X
	G (GE)[4]				X	
17 N	G–2	X	X	X		
	G–1	X	X	X		
	G	X	X	X		X
18 W	G–2	X	X	X		
	G–1	X	X	X		
	G	X	X	X		X
18 E	G–2	X	X	X		
	G–1	X	X	X		
	G	X	X	X		X
Democracy Boulevard	G–2				X	
	G–1				X	
	G–East	X	X	X		X
	G–West				X	X

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[1] In the Before phase, time-lapse data were collected at each site of evaluator deployment on 2 days, 1 week apart: (1) one week prior to actual tapeswitch deployment; designated as "Pre-eval." and (2) on the day that manually coded data were collected at each evaluator site ("With-eval."). The purpose was to attempt assessment of the effects of data collection with the evaluator, e.g., in-vehicle noise generated by tires over the tapeswitch, visual detection of tapeswitches by motorists. "Non-eval." indicates data collection by time-lapse films only; i.e., the Traffic Evaluator was not deployed at such sites. In the After phase, "With-eval." and "Non-eval." films were made. No "Pre-eval." films were made in the After study.

[2] These were administered on or beyond the exit ramp to exiting motorists.

[3] This is the first exit at this interchange encountered by southbound motorists. W-P indicates Washington and Potomac, destinations for which this exit is appropriate.

[4] This is the second exit at this interchange encountered by southbound motorists. GE indicates Glen Echo, a destination for which this exit is appropriate.

Table 3
Data Collection Summary Table: BEFORE Phase

Date and Weather	Data Collected						Interchange and Sign	Comment
	Traffic Evaluator	Manual Coding	Time-Lapse[1]			Inter-view		
			With Eval.	Pre-Eval.	Non-Eval.			
8/17 Clear				X			Democracy Gore East	
8/18 Overcast light rain					X		Democracy G–2	Scheduled dates exchanged because of sign changes at Interchange 17 on 8/18/71.
8/19				X			17 North Gore	
8/23 Clear	X						Democracy Gore	
8/24 Clear	X	X	X				Democracy Gore	
				X			18 West G–1 (Control)	
8/25 Clear	X	X	X				17 North Gore	
				X			16 North G–1	
8/26	X						17 North Gore	
					X		Democracy G–1	
8/30	X						18 West G–1 (Control)	
8/31 Clear	X	X	X				18 West G–1 (Control)	
				X			15 North Gore	
9/1 Rain	X	X	X				16 North G–1	
				X			18 East Gore	
9/2 Overcast	X						16 North G–1	
					X		16 North G–2	
9/6 Clear	X						15 North Gore	
		X			X		17 North Gore	Special study for Labor Day traffic. Traffic counts and vehicle identification done without evaluator.
					X		17 North G–1	
9/7 Clear	X	X	X				15 North Gore	
				X			16 North Gore	
9/8 Clear	X	X	X				18 East Gore	
				X			17 North G–1	Error. Should have been 18 North G–2, "Pre-eval." photos rescheduled for 9/22/71.

[1] In the Before phase, time-lapse data were collected at each site of evaluator deployment on 2 days, 1 week apart: (1) one week prior to actual tapeswitch deployment; designated as "Pre-Eval." and (2) on the day that manually coded data were collected at each evaluator site ("With Eval."). The purpose was to assess the effects of data collection with the evaluator, e.g., vehicle noise generated by tires over the tapeswitches, visual detection of tapeswitches by motorists. In the Acclimation and After phases, no Pre-Eval. films were taken. "Non-Eval." indicates data collection by time-lapse films only; i.e., the traffic evaluator was not deployed at such sites.

Table 3 (Continued)
Data Collection Summary Table: BEFORE Phase

Date and Weather	Data Collected						Interchange and Sign	Comment
	Traffic Evaluator	Manual Coding	Time-Lapse[1]			Inter-view		
			With Eval.	Pre-Eval.	Non-Eval.			
9/9 Clear					X		16 North Ramp	
9/13 Overcast								Traffic evaluator data collection was scheduled at 16 North Gore. Rain prevented tapeswitch deployment on schedule.
9/14 Clear				X			17 North G–2	Time-lapse photographs and traffic evaluator data collection were scheduled at 16 North Gore. Again rain prevented deployment. Rescheduled data collection to 9/16, weather permitting.
9/15 Clear	X	X	X				18 East G–2	Weather finally permitted tapeswitch deployment.
				X			17 North G–1	
9/16 Clear	X	X	X				16 North Gore	See 9/14 comment.
					X		16 South G–2	
9/20	X						17 North G–2	
9/21 Cloudy with rain until noon. Then occasional sun	X	X	X				17 North G–2	
				X			18 West G–2 (Control)	
9/22 Clear first hour, then overcast	X	X	X				17 North G–1	
				X			18 West Gore (Control)	
				X			18 East G–2	See 9/8 comment.
9/23 Overcast					X		Democracy Gore West	
						X	18 East (Ramp)	Exiting motorist interviews.
						X	–	Error interviews at gas stations.
9/24						X	–	Thruput interviews at YMCA and Bethesda Congregational Church.
9/29 Clear	X		X			X	17 North Gore	Vehicular maneuver special study.
9/30 Some overcast	X		X			X		Continuation of above study.

[1] In the Before phase, time-lapse data were collected at each site of evaluator deployment on 2 days, 1 week apart: (1) one week prior to actual tapeswitch deployment; designated as "Pre-Eval." and (2) on the day that manually coded data were collected at each evaluator site ("With Eval."). The purpose was to assess the effects of data collection with the evaluator, e.g., vehicle noise generated by tires over the tapeswitches, visual detection of tapeswitches by motorists. In the Acclimation and After phases, no Pre-Eval. films were taken. "Non-Eval." indicates data collection by time-lapse films only; i.e., the traffic evaluator was not deployed at such sites.

Table 3 (Continued)
Data Collection Summary Table: BEFORE Phase

Date and Weather	Data Collected						Interchange and Sign	Comment
	Traffic Evaluator	Manual Coding	Time-Lapse[1]			Inter-view		
			With Eval.	Pre-Eval.	Non-Eval.			
10/4 Overcast	X						18 West G–2 (Control)	
10/5 Rain, Overcast	X	X	X				18 West G–2 (Control)	
				X			18 East G–1	
10/6 Clear	X	X	X				18 West Gore (Control)	
				X			16 South Gore	
10/7 Clear	X						18 West Gore (Control)	
					X		16 2nd Gore	
						X	16 North (Ramp)	Exiting motorist interviews.
						X	17 North (I-70S)	Exiting motorist interviews.
10/8 Clear						X	–	Thruput interviews at YMCA and Bethesda Congregational Church.
10/12 Clear	X	X	X				18 East G–1	Traffic evaluator data collection was also scheduled for the same site on 10/11. Rain did not permit tapeswitch deployment until 1 AM on 10/12.
10/13 Clear	X	X	X				16 South Gore	
10/14 Clear	X						16 South Gore	
					X		16 South G–1	
						X	18 West (Ramp)	Exiting motorist interviews.
						X	16 South (Ramp)	Exiting motorist interviews.
10/15 Clear						X	Democracy Blvd. (East & West Ramps)	Exiting motorists interviews.
10/21 Clear						X	16 North (Ramp)	Exiting motorists interviews — selected.
						X	17 North (I–70S)	
10/22 Overcast						X	18 West (Ramp)	

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[1] In the Before phase, time-lapse data were collected at each site of evaluator deployment on 2 days, 1 week apart: (1) one week prior to actual tapeswitch deployment; designated as "Pre-Eval." and (2) on the day that manually coded data were collected at each evaluator site ("With Eval."). The purpose was to assess the effects of data collection with the evaluator, e.g., vehicle noise generated by tires over the tapeswitches, visual detection of tapeswitches by motorists. In the Acclimation and After phases, no Pre-Eval. films were taken. "Non-Eval." indicates data collection by time-lapse films only; i.e., the traffic evaluator was not deployed at such sites.

Table 4

Data Collection Summary Table: AFTER Phase

Date and Weather	Data Collected						Interchange and Sign	Comment
	Traffic Evaluator	Manual Coding	Time-Lapse[1]			Inter-view		
			With Eval.	Pre-Eval.	Non-Eval.			
8/16 Clear					X		Democracy G–2	
8/21 Clear	X						Democracy Gore	
8/22 Clear	X	X	X				Democracy Gore	
8/23 Clear	X	X	X				17 North Gore	
8/24 Clear	X						17 North Gore	
					X		Democracy G–1	
8/29 Clear	X	X	X				18 West G–1	TES data collection was also scheduled for 8/28; however rain prevented tape-switch deployment
8/30 Clear	X	X	X				16 North G–1	
8/31 Clear	X						16 North G–1	
					X		16 North G–2	
9/4 Rain then Clear		X					15 North Gore	
		X			X		17 North Gore	Special study for Labor Day traffic
					X		17 North G–1	Traffic counts and vehicle identification done without evaluator
9/5 Overcast	X	X	X				15 North Gore	
9/6 Clear	X	X	X				18 East Gore	
9/7 Clear	X						18 East Gore	
					X		16 North Ramp	
						X	16 North (Ramp) 17 North (I–70S)	Exiting motorist Interviews
9/8 Clear						X		Thruput interviews at YMCA and Bethesda Congregational Church

[1] In the Before phase, time-lapse data were collected at each site of evaluator deployment on 2 days, 1 week apart: (1) one week prior to actual tapeswitch deployment; designated as "Pre-Eval." and (2) on the day that manually coded data were collected at each evaluator site ("With Eval."). The purpose was to assess the effects of data collection with the evaluator, e.g., vehicle noise generated by tires over the tapeswitches, visual detection of tapeswitches by motorists. In the Acclimation and After phases, no Pre-Eval. films were taken. "Non-Eval." indicates data collection by time-lapse films only; i.e. the traffic evaluator was not deployed at such sites.

Table 4 (Continued)
Data Collection Summary Table: AFTER Phase

Date and Weather	Data Collected						Interchange and Sign	Comment
	Traffic Evaluator	Manual Coding	Time-Lapse[1]			Inter-view		
			With Eval.	Pre-Eval.	Non-Eval.			
9/11 Clear then Overcast	X						16 North Gore	
9/12 Rain	X	X	X				16 North Gore	
9/13 Overcast	X	X	X				18 East G–2	
9/14 Overcast	X						18 East G–2	
					X		16 South G–2	
						X	18 West Ramp	Exiting motorist Interviews
						X	16 South (Ramp)	
9/15 Clear						X		Thruput interviews at YMCA and Bethesda Congregational Church
9/18 Overcast	X						17 North G–2	
9/19 Overcast	X	X	X				17 North G–2	
9/20 Overcast	X	X	X				17 North G–1	
9/21 Rain	X						17 North G–1	Interviewing was scheduled but cancelled due to rain
					X		Democracy Gore West	
9/22 Overcast						X		Thruput interviews at YMCA and Bethesda Congregational Church
9/25 Overcast	X						18 West G–2 (Control)	
9/26 Overcast	X	X	X				18 West G–2 (Control)	
9/27 Rain	X	X	X				18 West Gore (Control)	
9/28 Overcast	X						18 West Gore (Control)	
					X		16 South 2nd Gore	
						X	Democracy Blvd (East & West Ramps)	Exiting motorist interviews.
							18 East (Ramp)	Exiting motorist interviews.

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[1] In the Before phase, time-lapse data were collected at each site of evaluator deployment on 2 days, 1 week apart: (1) one week prior to actual tapeswitch deployment; designated as "Pre-Eval." and (2) on the day that manually coded data were collected at each evaluator site ("With Eval."). The purpose was to assess the effects of data collection with the evaluator, e.g., vehicle noise generated by tires over the tapeswitches, visual detection of tapeswitches by motorists. In the Acclimation and After phases, no Pre-Eval. films were taken. "Non-Eval." indicates data collection by time-lapse films only; i.e., the traffic evaluator was not deployed at such sites.

Table 4 (Continued)

Data Collection Summary Table: AFTER Phase

Date and Weather	Data Collected						Interchange and Sign	Comment
	Traffic Evaluator	Manual Coding	Time-Lapse[1]			Inter-view		
			With Eval.	Pre-Eval.	Non-Eval.			
9/29						X	18 East (Ramp)	Exiting motorist interviews—selected.
10/2 Clear	X						18 East G–1	
10/3 Clear	X	X	X				18 East G–1	
10/4 Overcast	X	X	X				16 South Gore	
10/5 Overcast	X						16 South Gore	
					X		16 South G–1	
						X	16 North (Ramp)	Exiting motorist interviews — selected.
						X	17 North (I–70S)	

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[1] In the Before phase, time-lapse data were collected at each site of evaluator deployment on 2 days, 1 week apart: (1) one week prior to actual tapeswitch deployment; designated as "Pre-Eval." and (2) on the day that manually coded data were collected at each evaluator site ("With Eval."). The purpose was to assess the effects of data collection with the evaluator, e.g., vehicle noise generated by tires over the tapeswitches, visual detection of tapeswitches by motorists. In the Acclimation and After phases, no Pre-Eval. films were taken. "Non-Eval." indicates data collection by time-lapse films only; i.e., the traffic evaluator was not deployed at such sites.

The tapeswitches were always deployed in pairs with a separation of four feet. This separation was attained with an accuracy of ±1/4 of an inch or about ±0.5 percent. The distance between pairs was 300 feet, and the total length of the tapeswitch array was 1500 feet. In the Traffic Evaluator System, speed is measured within pair members by the time difference of a given axle striking each switch in the pair. Deployment in pairs also provides redundancy since after a pair is traversed, wheelbase is calculated from speed and the time difference between the front and rear axle crossing of a single switch. With the wheelbase figure, speed can be calculated at single switches in the event a switch fails, as sometimes happens.

The number of pairs available for roadway instrumentation is limited by the capability of the evaluator data recorder system. This limitation is 60 inputs, each tapeswitch and each manual code button counted as one. One manual coder is required for each lane coded. If each coder uses an eight-button keyboard, a total of eight code button inputs are used per lane. A 1500-foot array of switches in pairs at 300-foot intervals requires 12 switches per lane. With eight codes and 12 road switches, a total of 20 inputs is used per lane. Thus, instrumentation and coding of three lanes requires all 60 inputs. Clearly, where roadway geometrics deviate from the straight through situation with three lanes, some tradeoffs are necessary since instrumentation of all lanes with provision for manual coding may not be possible. In addition to the number of tapeswitches, their location in relation to study areas of interest must also be considered. The results of these tradeoffs are described below.

Advance Signs. The Traffic Evaluator System was deployed at seven advance or exit direction signs (four G-2 signs, and three G-1 signs). At two of these sites, the G-2 and G-1 signs at Interchange 17 northbound, the Beltway is four lanes wide. With 20 of the available 60 evaluator inputs required per lane, one lane had to be omitted from instrumentation. Numbering from the right-hand shoulder, Lane 1 was omitted. The decision to omit this lane was based upon the instrumentation decision at the gore of this major fork interchange. Early field observations showed that the least interesting lane at the gore from a traffic maneuver point of view was Lane 1. Lane 1 was therefore not instrumented at the gore. For consistency and comparability at all sites studied with the Traffic Evaluator System at Interchange 17, the advance and exit direction signs were similarly instrumented. Tapeswitches were deployed in Lanes 2, 3, and 4 only at these signs.

For the remaining five advance and exit direction sign locations, there were three lanes of traffic. Therefore, all lanes were instrumented at these sites.

The 1500-foot tapeswitch array was deployed symmetrically around each advance sign. Tapeswitches extended from 750 feet upstream to 750 feet downstream from the sign. The decision to symmetrically position the tapeswitch array such that it extended from 750 feet upstream to 750 feet downstream at advance and exit direction signs was based first on observation of vehicles maneuvering at the exit direction sign for 17 North. As many maneuvers occurred upstream from the sign as occurred downstream and the distances over which maneuvers occurred upstream and downstream were roughly identical. Second, the placement of the first tapeswitch pair 750 feet upstream from these signs is compatible with the design rule of thumb (derived from Forbes & Holmes, 1939) which relates legibility to distance by 50 feet per inch of letter height. Lower case letters on the advance direction signs were either 12 inches or 15 inches (see Chapter III, Guide Signing). At 50 feet per inch, lower case letters should be legible at 600 feet or 750 feet, respectively. Admittedly, this rule does not take into account visual angle, dynamic visual acuity, and individual differences in the driver population; some of which would increase, others decrease, legibility distance. More importantly for this project, the rule does not consider decision and reaction time. These will determine the points at which changes in speed, vehicle position, etc. will occur.

Decision and reaction time reduce the distance at which tapeswitches should be placed below those derived from calculations based entirely on legibility. Also, drivers at advance signs may not elect to respond to an upcoming exit until they are closer to the gore. Consideration of all the above suggested that the appropriate location for the tapeswitches was symmetrical; 750 feet upstream and 750 feet downstream from advance and exit direction signs.

Gore Signs. The Traffic Evaluator System was deployed at seven gore sign locations. Gore area instrumentation is more complex than advance sign instrumentation because of changing roadway geometrics at these locations. An example is the addition of deceleration lanes of varying lengths. Another complication is that the location of the gore sign itself varies slightly in relation to the actual geometry of the road and its pavement markings. This means that tapeswitch deployment must be based upon consideration of the eventual data analyses to be undertaken. The following guidelines summarize key aspects of gore area tapeswitch deployment:

- Where an exit included a deceleration lane, tapeswitches were deployed into the deceleration lane and in the exit lane continuing from it, even if this meant sacrificing instrumentation of one or more high speed lanes. This guideline ensured that movements of traffic around the exit point could be studied.

- The fifth group of switch pairs (numbering from the most upstream pair) was located at the tip of the painted gore. Therefore, the 1500-foot array of tapeswitches extended from 1200 feet upstream from the painted gore to 300 feet downstream from it.

The tip of the painted gore is a key point because traffic correctly negotiating the interchange does not cross into the painted gore area. In other investigations, where erratic maneuvers have been counted as measures of traffic performance, crossing the painted gore was considered one such maneuver. The gore sign was located in all cases within 150 feet of the fifth group of switch pairs.

Table 5 on the following page summarizes the lanes instrumented with tapeswitches at each Traffic Evaluator System measurement site. Following the table, Figure 5 shows actual instrumentation of each gore site. It will be noted that Interchange 17 is exceptional. At this interchange, the distance from the tip of the painted gore to the physical barrier (guardrail) preventing passage over the gore is about 500 feet. Therefore, the sixth set of switches was located at this barrier, the end of a guardrail. It will be noted that the fifth set of switches is located within 150 feet of the gore sign, as holds true at all other gore area sites.

For all gore sites, the sixth set of switches was at or beyond the point where a physical barrier prevents last minute movement into or out of the exit ramp.

Data Collection in the Acclimation Phase

General

In the Before/After study, the data collection schedule was designed to minimize seasonal differences, both environmental and those attributable to changes in the proportions of familiar and unfamiliar motorists, which might confound measurement of the effects of the conventional and diagrammatic signs. Thus, Before and After data collection efforts at each site were separated by exactly one year (minus two days to achieve week day constancy).

In the Acclimation study, the objective was to evaluate the immediate effect of a change in signing on motorist behavior. The Acclimation study was also a before/after study but before and after data collection efforts were separated by one day rather than one year. The basic design was:

1. Collect baseline data on Tuesday under the conventional signing condition.

2. Change signs from conventional to diagrammatic on Wednesday.
3. Collect data on Thursday and Friday under the diagrammatic signing condition.
4. Collect follow-up data on the Thursdays of succeeding weeks (not necessarily each week) for up to six weeks.

Table 5

Lanes Instrumented with Tapeswitches in the Before/After Study

Interchange	Sign	Number of Lanes	Lanes Instrumented*
15 N	G	3	1, 2, 3
16 N	G–2	3	–
	G–1	3	1, 2, 3
	G	3	1, 2, 3
	Ramp	1	–
16 S	G–2	4	–
	G–1	4	–
	G	4	1, 2, E*
	G	4/3**	–
17 N	G–2	4	2, 3, 4
	G–1	4	2, 3, 4
	G	4	2, 3, 4
18 E	G–2	3	1, 2, 3
	G–1	3	1, 2, 3
	G	3	1, 2, D/E*
18 W	G–2	3	1, 2, 3
	G–1	3	1, 2, 3
	G	3	1, 2, D/E*
Democracy Boulevard	G–2	2	–
	G–1	2	–
	G (East)	2	1, 2, D/E*
	G (West)	2	–

*E indicates tapeswitches were deployed in the exit ramp.

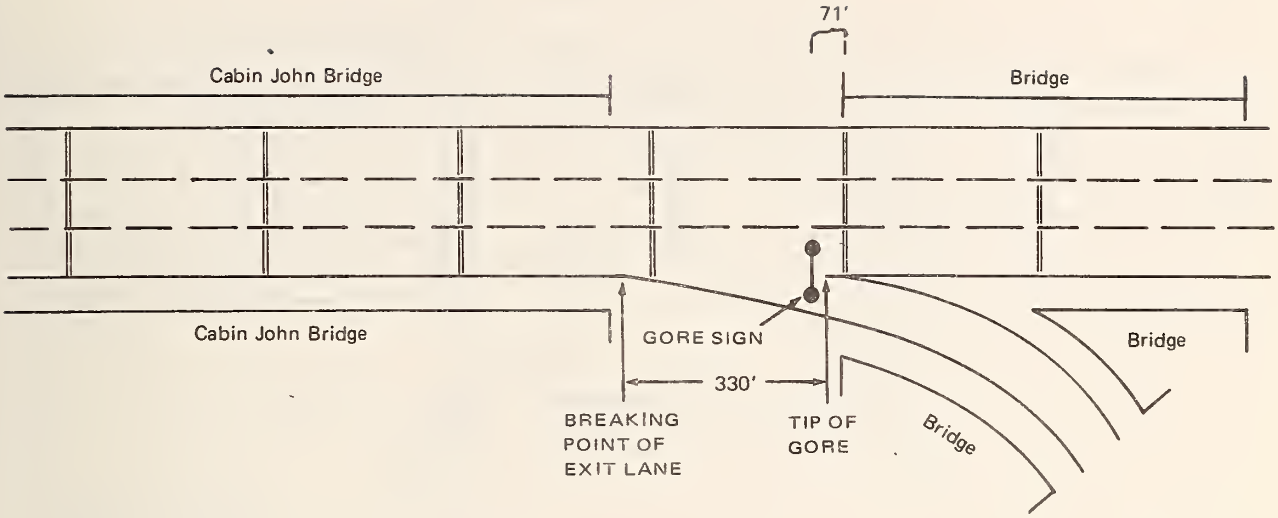
D/E indicates tapeswitches were deployed in the exit ramp and in the deceleration lane which preceded it.

**Lane 1 is dropped at the gore.

–Indicates the Traffic Evaluator System was not used at this site.

The Acclimation phase study was conducted at two interchanges, 17 northbound and 16 southbound during the spring of 1972. The studies at each interchange were done consecutively and did not overlap. Data collection at 17 North began on Tuesday, February 8, 1972 and was completed on Thursday, March 23, 1972. Acclimation phase data collection at 16 South began on Tuesday, April 18, 1972 and was completed on Thursday, May 25, 1972.

Exit 15N Gore



Exit 16N Gore

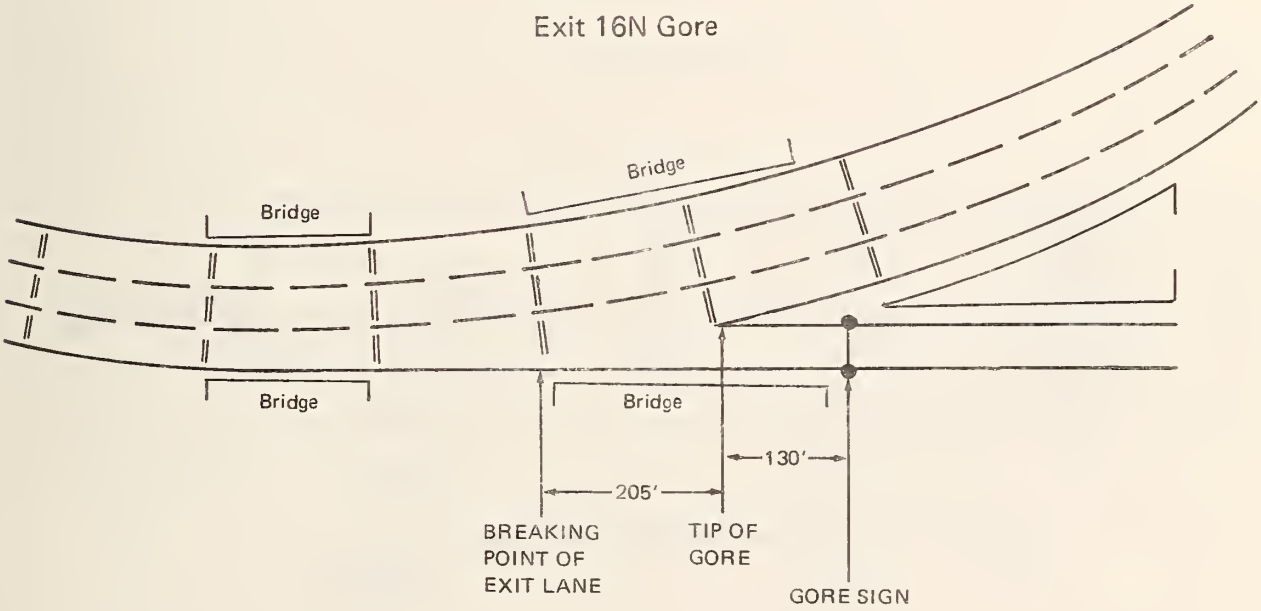
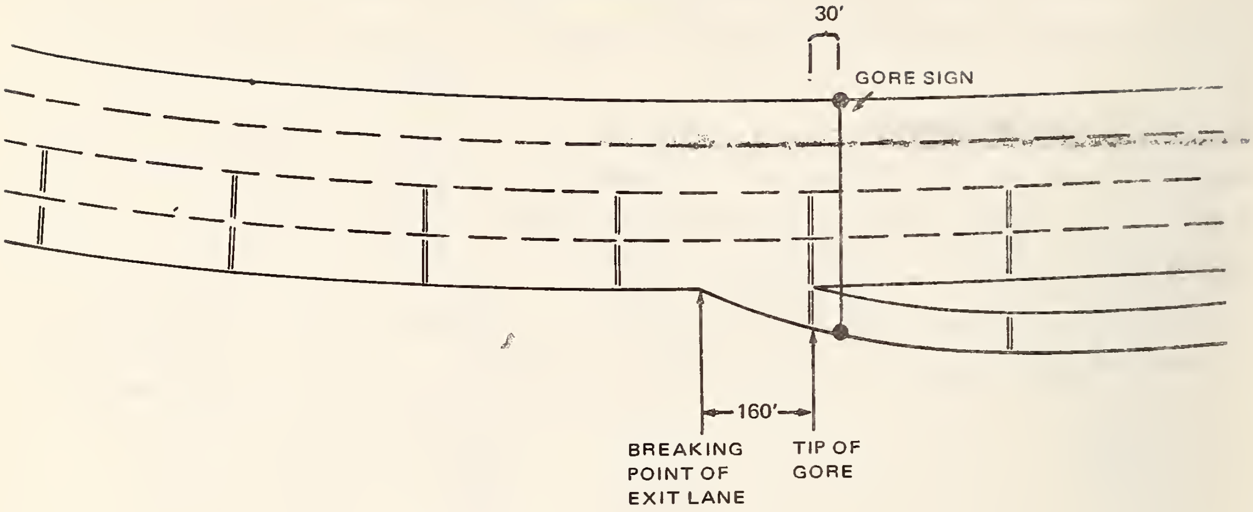


Figure 5. Tapeswitch instrumentation at each gore. Tapeswitch pairs are separated by 300 feet and pair members are separated by 4 feet.

Exit 16S Gore



Exit 17N Gore

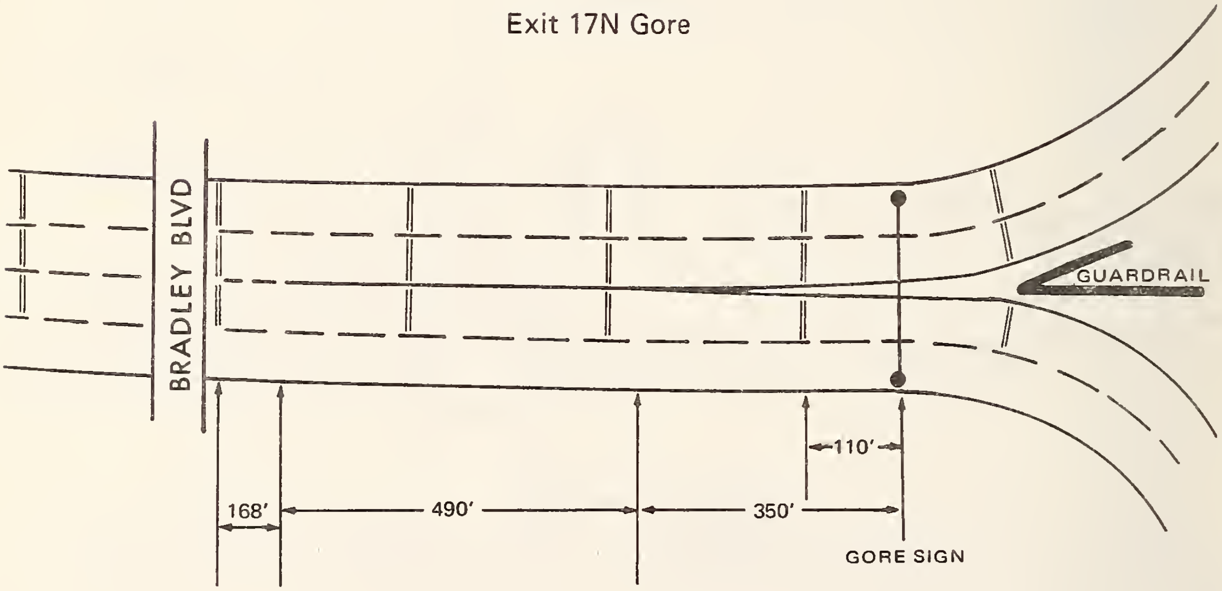
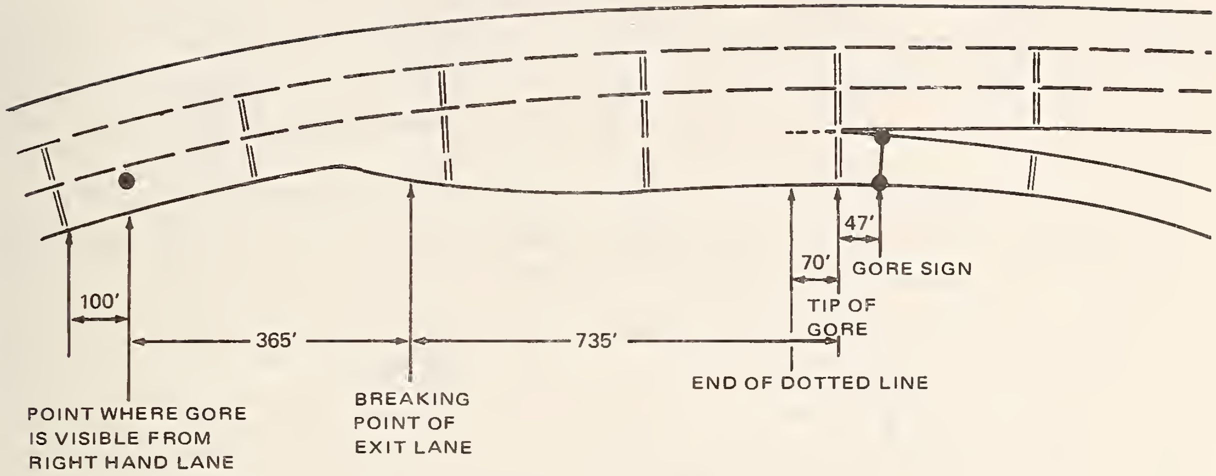


Figure 5 (Cont'd.). Tapeswitch instrumentation at each gore. Tapeswitch pairs are separated by 300 feet and pair members are separated by 4 feet.

Exit 18W Gore (Control Site)


100'
365'
735'
70'
47'
GORE SIGN
TIP OF GORE
END OF DOTTED LINE
POINT WHERE GORE IS VISIBLE FROM RIGHT HAND LANE
BREAKING POINT OF EXIT LANE

Exit 18E Gore

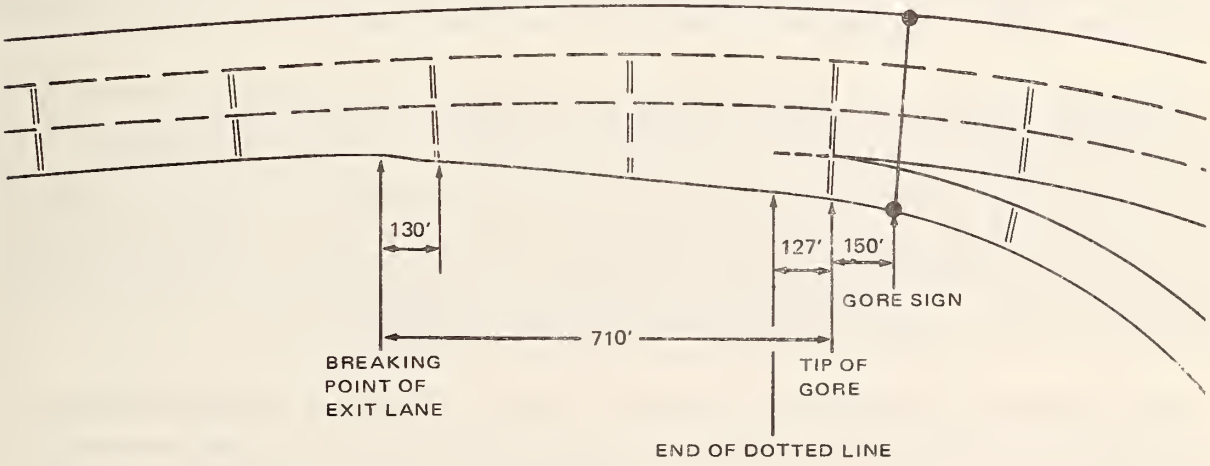


Figure 5 (Cont'd.). Tapeswitch instrumentation at each gore. Tapeswitch pairs are separated by 300 feet and pair members are separated by 4 feet.

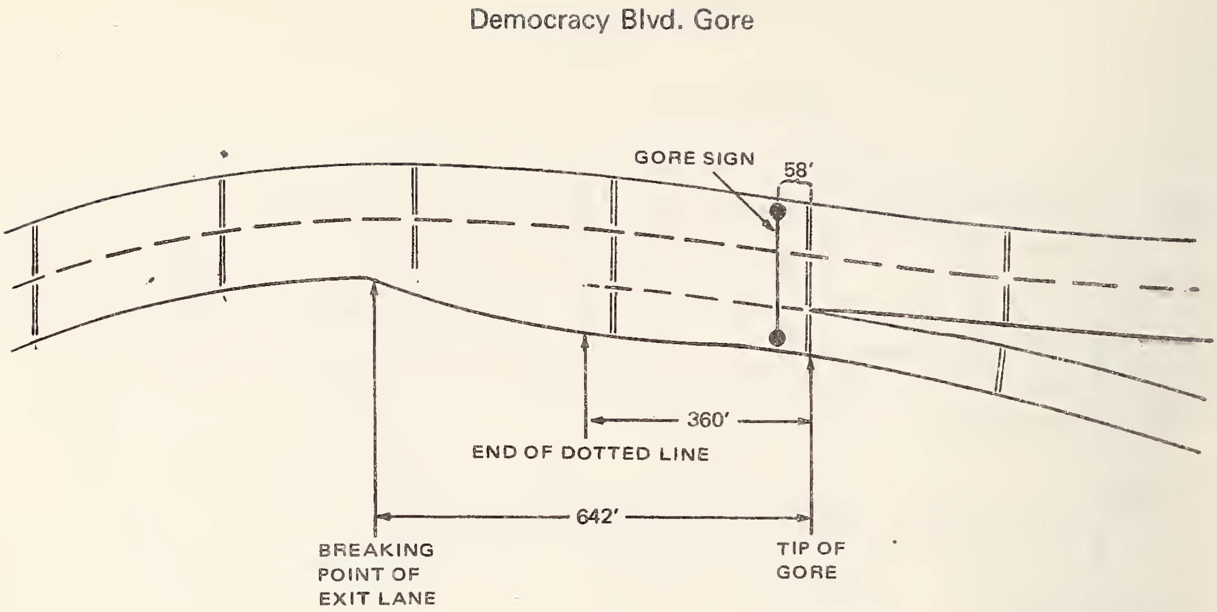


Figure 5 (Cont'd.). Tapeswitch instrumentation at each gore. Tapeswitch pairs are separated by 300 feet and pair members are separated by 4 feet.

These two interchanges were selected for study because they posed particularly interesting geometric and/or perceptual problems for the motorist. Interchange 17 North is a left exit major fork with the left two of four lanes exiting as I-70S. The right two lanes continue as I-495. In plan view, this interchange is extremely simple. However, drivers found it difficult under the conventional signing condition. Evidence for this was found in the high proportion of erratic maneuvers to the left and to the right in the Before study.

Interchange 16 South is a complex interchange including a collector-distributor, two exit ramps from I-495 and a lane drop at the second exit. At the second exit, the right-hand lane (Lane 1) of the four through traffic lanes continues as the exit ramp, leaving three through traffic lanes beyond this point. Considerable weaving activity was found around the first gore and in the section between the first and second gores at this interchange in the Before phase. Therefore, it was also selected for investigation in the Acclimation phase.

The Acclimation phase investigations differed from the Before/After study in that during the Acclimation phase, data were collected at all sign locations for a given test interchange simultaneously. Thus, data were collected in parallel at the advance, exit direction and gore sign locations for a total of three signs at 17 North and four signs at 16 South. Three data collection techniques were used; the TES, time-lapse films and responses of exiting motorists to a questionnaire, but not all techniques were used at all sign locations.

Traffic Evaluator System. At 17 North, TES data were collected at the gore location on Tuesday, Thursday, and Friday of the week of signing change. At 16 South, TES data were collected at the first gore and at the advance sign location on Tuesday, Thursday, and Friday of the week of signing change. TES data were also collected at these two sign locations of Interchange 16 South on the third Thursday after signing change.

The TES data collection interval was 0800 to 1430 as compared to the 0930 to 1430 interval used in the Before/After study. The reason for expansion of the interval was that it allowed collection of some rush hour traffic. Because there was particular interest in the reaction of local drivers during the Acclimation phase, it was felt that rush hour should be included. A problem remained in whether the buffer memory would be so exceeded by rush hour volumes as to invalidate the data. While there was evidence that the storage capacity of the TES was sometimes exceeded in this period, this did not occur to a sufficient degree to invalidate the data.

The manual coding procedure during the Acclimation phase was changed compared to the Before/After study. Manual coding was done at gore sign sites on each day TES data were collected for two 1/2-hour periods (1015 to 1045 and 1100 to 1130). Only one code button was used and this was pressed only for nonlocal vehicles, regardless of type. The reduction in total time spent coding and the change in the keyboard was done because of the cold weather conditions which occurred during the Acclimation phase. The eight push button keyboard was extremely difficult to use with gloves. In addition, criteria had been developed to separate vehicles into five categories on the basis of wheelbase as measured by the TES.

Time-Lapse Photography. Time-lapse films were made at the three guide sign locations of 17 North and the four guide sign locations of 16 South on Tuesday, Thursday, and Friday of the week of signing change and on Thursdays of subsequent weeks. For 17 North, the last set of films was made six weeks after the week of signing change. For 16 South, the last set of films was made five weeks after the week of signing change. On those days where TES data were collected (the week of signing change at both interchanges and the follow-up Thursday three weeks after signing change at 16 South), the film schedule was:

0800–0830
1100–1130
1400–1430

On most other days, only one film was made at each site, 1400–1430.

Questionnaires. Questionnaire data were collected between 1200 and 1500 on Tuesday, Thursday, and Friday of the week of signing change. Motorists exiting onto I-70S at Interchange 17 North and at the first gore at Interchange 16 South were flagged off by a State Trooper. As in the Before/After study, demand sampling was followed. The questionnaire form used was the same form as was given to exiting motorists in the Before/After study (see Appendix B).

Study Sites By Measurement System and Calendar Date

Table 5 on the following page summarizes the seven study sites and the measurement systems used at each related to calendar date. The particular time at which each 30-minute time-lapse film was begun are noted in the table. As can be seen, between one and three films were made at each site on each day.

Traffic Evaluator System Tapeswitch Deployment

Each of the Acclimation phase data collection sites involved at least four lanes (five at the gore of Interchange 16 South when the exit ramp is counted). In the Before/After study, a maximum of three lanes were instrumented because of the 60-input limitation of the TES. However, reduction of the number of manual code inputs during the Acclimation phase permitted instrumentation of additional lanes.

17 North. An additional pair of switches was placed in Lane 1 at the location of Trap 3[1]. This permitted the possibility of a total traffic count across all four lanes of this interchange.

16 South. In the Before/After study, Lanes 1 and 2 and the exit ramp were instrumented at the gore. In the Acclimation phase, Lane 3 was also fully instrumented and a pair of switches was deployed at Trap 1 in Lane 4.

Figure 6 displays the tapeswitch instrumentation at the gore at 16 South and 17 North.

---

[1] Tapeswitches are deployed in pairs with pair numbers separated by four feet. Each pair may be called a trap. Traps are numbered consecutively in the downstream direction. In this study, there were generally six traps per lane from Trap 1, the first trap encountered by a vehicle, to Trap 6, 1500 feet downstream.

Table 6
Data Collection Summary Table: ACCLIMATION Phase

Date and Weather	Data Collected						Interchange and Sign	Comment
	Traffic Evaluator	Manual Coding	Time-Lapse[1]			Inter-view		
			With Eval.	Pre-Eval.	Non-Eval.			
2/8 Clear	X	X	X			X	17 North Gore	Film schedule: 0800, 1100, 1400
					X		17 North G–1	
					X		17 North G–2	
2/10 Clear	X	X	X			X	17 North Gore	Film schedule: as above
					X		17 North G–1	
					X		17 North G–2	
2/11 Clear	X	X	X			X	17 North Gore	Film schedule: as above
					X		17 North G–1	
					X		17 North G)2	
2/17 Snow					X		17 North Gore	Film schedule: 1100, 1400, Snow during filming.
					X		17 North G–1	
					X		17 North G–2	
2/24 Overcast					X		17 North Gore	Film schedule: 1400. 1/2" melting snow on ground. Road dry
					X		17 North G–1	
					X		17 North G–2	
3/2 Sun; intermittent cloudiness					X		17 North Gore	Film schedule: 1400
					X		17 North G–1	
					X		17 North G–2	
3/9 Clear					X		17 North Gore	Film schedule: 1400
					X		17 North G–1	
					X		17 North G–2	
3/23 Bright overcast					X		17 North Gore	Film schedule: 1400
					X		17 North G–1	
					X		17 North G–2	
4/18 Clear	X	X	X			X	16 South Gore 1	Film schedule: 0800, 1100, 1400
					X		16 South Gore 2	
					X		16 South G–1	
	X		X				16 South G–2	
4/20 Overcast; rain showers 0800 – 0830	X	X	X			X	16 South Gore 1	Film schedule: as above
					X		16 South Gore 2	
					X		16 South G–1	
	X		X				16 South G–2	
4/21 Clear	X	X	X			X	16 South Gore 1	Film schedule: as above
					X		16 South Gore 2	
					X		16 South G–1	
	X		X				16 South G–2	
5/4 Clear					X		16 South Gore 1	Film schedule: 1400
					X		16 South Gore 2	
					X		16 South G–1	
					X		16 South G–2	

[1] In the Before phase, time-lapse data were collected at each site of evaluator deployment on 2 days, 1 week apart: (1) one week prior to actual tapeswitch deployment; designated as "Pre-Eval." and (2) on the day that manually coded data were collected at each evaluator site ("With Eval."). The purpose was to assess the effects of data collection with the evaluator, e.g., vehicle noise generated by tires over the tapeswitches, visual detection of tapeswitches by motorists. In the Acclimation and After phases, no Pre-Eval. films were taken. "Non-Eval." indicates data collection by time-lapse films only; i.e., the traffic evaluator was not deployed at such sites.

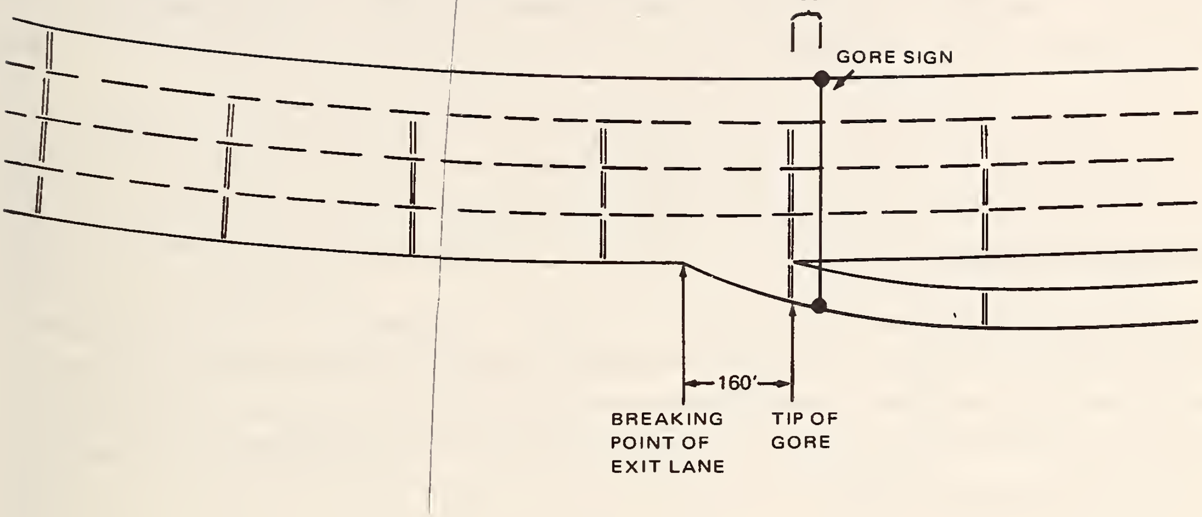
Table 6 (Continued)
Data Collection Summary Table: ACCLIMATION Phase

Date and Weather	Data Collected						Interchange and Sign	Comment
	Traffic Evaluator	Manual Coding	Time-Lapse[1]			Inter-view		
			With Eval.	Pre-Eval.	Non-Eval.			
5/11 Clear	X	X	X			X	16 South Gore 1	Film schedule:
					X		16 South Gore 2	0800, 1100, 1400
					X		16 South G–1	
	X		X			X	16 South G–2	
5/18 Overcast; occasional sun and a little rain					X		16 South Gore 1	Film schedule:
					X		16 South Gore 2	1400
					X		16 South G–1	
					X		16 South G–2	
5/25 Overcast; occasional sun					X		16 South Gore 1	Film schedule:
					X		16 South Gore 2	1400
					X		16 South G–1	
					X		16 South G–2	

---

[1] In the Before phase, time-lapse data were collected at each site of evaluator deployment on 2 days, 1 week apart: (1) one week prior to actual tapeswitch deployment; designated as "Pre-Eval." and (2) on the day that manually coded data were collected at each evaluator site ("With Eval."). The purpose was to assess the effects of data collection with the evaluator, e.g., vehicle noise generated by tires over the tapeswitches, visual detection of tapeswitches by motorists. In the Acclimation and After phases, no Pre-Eval. films were taken. "Non-Eval." indicates data collection by time-lapse films only; i.e., the traffic evaluator was not deployed at such sites.

Exit 16S Gore



Exit 17N Gore

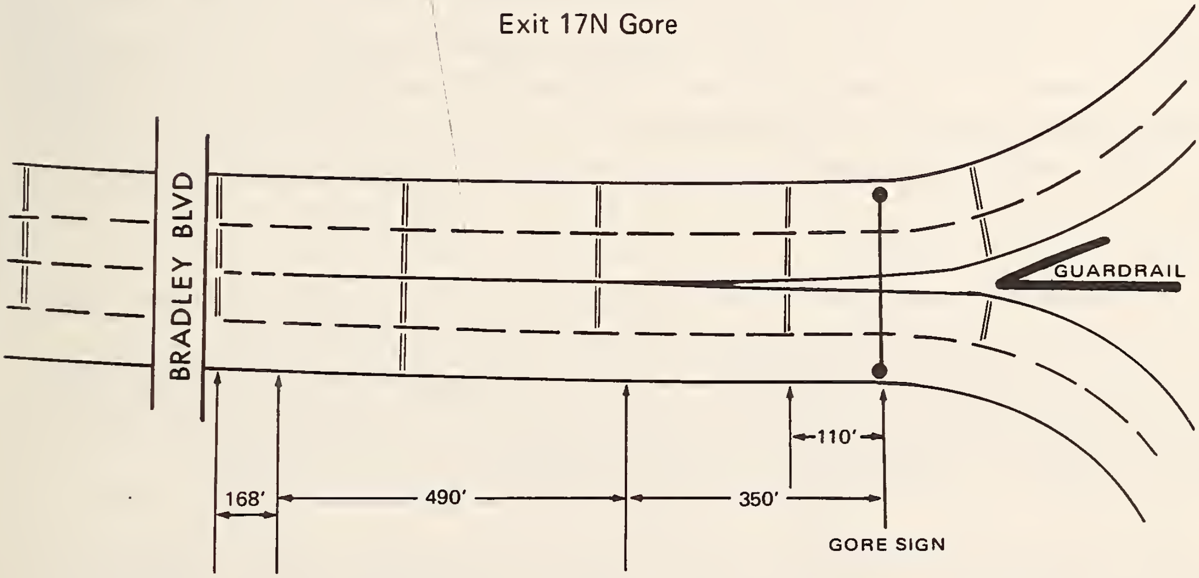


Figure 6. Tapeswitch instrumentation at gores in the Acclimation Phase. Compared to the Before/After study, an additional lane (Lane 3) at 16 South was fully instrumented. Also, one switch pair was deployed in the remaining uninstrumented lane at both 16 South and 17 North.

In the Before/After study, the advance (G-2) sign of 16 South was not instrumented. In the Acclimation study, three of the four lanes (Lanes 1, 2, and 3) were fully instrumented (12 switches or 6 pairs/lane) and one pair of switches was located at Trap 1 in Lane 4. The location of the six traps in each lane in relation to the sign was the same as was used at advance and exit direction signs in the Before/After study. That is, the traps were deployed symmetrically about the sign. Thus, the highway was instrumented from 750 feet upstream to 750 feet downstream from the sign.

Data Reduction

Traffic Evaluator System

From the continuous binary data recorded in the field, a preliminary "Edit" program identifies unique periodic 18-bit groups which are recorded every 2.016 seconds. This group, caused by the internal clock overflow, is used to synchronize the program which proceeds to separate the data into characters comprised of a time and switch code. During the Edit process extensive error checking is accomplished.

The edited data tape is then processed by a flexible "Analysis" program. This program identifies related pairs of switches which constitute an axle passage, determines the time difference across the 4-foot switch pair separation, and calculates an axle speed. Axles which are recorded that are within 30 feet of a previous axle are tentatively grouped with the previous axle until a complete vehicle passage has been recognized. The initial appearance of this vehicle with calculated parameters of speed, wheelbase and number of axles is entered into an array of tables corresponding to the lane and pair number at which the vehicle was recognized.

When a vehicle is reconstructed at other than the entry pair of switches, the table for the previous pair in the same lane is examined for a vehicle with characteristics which match. If none is found, the tables for all other lanes are examined to detect a lane change. Data on recognized vehicle matches are moved from table to table until the vehicle is tracked to the last pair of switches. All data regarding the reconstructed vehicle is then recorded.

For ease of further processing, the time and speed of the previous vehicle at each pair is used to calculate time and space headway; similarily, the next vehicle's arrival is used to calculate "tailway."

The failure of one switch in any pair is noted by the program which causes an extensive subroutine to reconstruct the missing code for all vehicles based on the calculated wheelbase until a successful link is made. In all cases, the speed of a vehicle averaged between successive pairs compared to the measured speed at the pairs is required to be appropriate to the general acceleration/deceleration capabilities of motor vehicles. This constraint is an input to the program and is changed to reflect the characteristics of the instrumented site.

A number of other characteristics of traffic behavior are calculated as the vehicles are reconstructed. Vehicles are assigned to one of five types based on wheelbase and number of axles as compared to a table of typical configurations. Array-dependent platoons are identified based on either time or distance separation. The same platoon number is assigned to all vehicles within a given platoon.

An important feature of the analysis program is its capability to determine when failures of road switches occurred. Original data which are missing from the input file of times and switch numbers can frequently be reconstructed and used by the program without causing the vehicle to be lost from the output data file. Many internal checks are performed before permitting the reconstruction of missing data, and the output can be used with great confidence.

The printed output can take many forms, some of which are shown in Figures 7 and 8. Figure 7 first shows the number of vehicles, by major type, identified at each pair of switches and for each lane that was instrumented. This is followed by a set of tables that record lane straddles at each pair of switches. Next is a table giving the number of lane changes recorded at each switch pair. Three sets of eight manually operated event switches can be used when recording data in the field. A table showing the total number of each event recorded during the analysis interval is printed. Finally, four tables are printed for each switch pair in the grid. These give histogram data for absolute and relative speeds, time headway, and space headway. The range and class size for the tables are established by the user to fit the field conditions.

Specific vehicle information is shown in Figure 8. Included are a unique identification number for each vehicle detected, the vehicle type (auto or nonauto), the lane traversed and switch pair crossed within the lane. The analysis period, platoon number, and number of axles on the vehicle are also recorded. Associated with this information each record presents the front axle speed, the rear axle speed, the time each axle reached the switch, average vehicle speed, the distance between the first two axles, time and space headway between the current vehicle and the preceding one, space tailway, the manual observer code (if any) and the clock time in hours, minutes, and seconds. The beginning clock time is established by the user through an input parameter.

Vehicles Identified by Type

```
                              DIAGRAMMATIC SIGNING STUDY

                              15E
                              G-2
                              9/13/72
                              0930 - 1430

                              ANALYSIS PERIOD  0930 - 1430


NO. PLATOONS IDENTIFIED =  263

NO. VEHICLES (BY TYPE) CROSSING EACH DETECTOR PAIR

LANE      PAIR 1          PAIR 2          PAIR 3         PAIR 4         PAIR 5          PAIR 6
         AUTO  NONAUTO   AUTO  NONAUTO   AUTO  NONAUTO  AUTO  NONAUTO  AUTO  NONAUTO   AUTO  NONAUTO

  1     1808     224    1780     221    1768     231   1737     227  1700     226    1686     226
  2     2710      80    2706      80    2695      76   2697      79  2665      76    2652      79
  3     1000       7    1020       6    1070       7   1086       7  1131       7    1160       6


TOTALS  5518     311    5506     307    5533     314   5520     313  5496     309    5498     311
```

Lane Straddles

1 — 2 as a column heading indicates that the vehicle is straddling Lanes 1 and 2 and is changing from Lane 1 to Lane 2.

```
LANE STRADDLES

PAIR                      VEHICLE ORIENTATION
              1-2     2-1     2-3     3-2     3-4     4-3

  1             3       2       4       0      0       0
  2            28      22      34       9      0       0
  3            41      24      20      16      0       0
  4            20      41      15      27      0       0
  5            27      39      19      25      0       0
  6            31      24      32      21      0       0
```

Figure 7. Several types of TES output.

Lane Changes Between Detector Pairs

```
LANE CHANGES BETWEEN DETECTOR PAIRS 2 AND 1

FROM LANE                  TO LANE
                      1       2      3

   1                  0      49      1     50
   2                 30       0     30     60
   3                  1      17      0     18

TOTALS               31      66     31    128
```

```
LANE CHANGES BETWEEN DETECTOR PAIRS 3 AND 2

FROM LANE                  TO LANE
                      1       2      3

   1                  0      62      4     66
   2                 48       0     65    113
   3                  0      24      0     24

TOTALS               48      86     69    203
```

```
LANE CHANGES BETWEEN DETECTOR PAIRS 4 AND 3

FROM LANE                  TO LANE
                      1       2      3

   1                  0      85      2     87
   2                 51       0     59    110
   3                  1      32      0     33

TOTALS               52     117     61    230
```

```
LANE CHANGES BETWEEN DETECTOR PAIRS 5 AND 4

FROM LANE                  TO LANE
                      1       2      3

   1                  0      71      1     72
   2                 49       0     83    132
   3                  2      28      0     30

TOTALS               51      99     84    234
```

```
LANE CHANGES BETWEEN DETECTOR PAIRS 6 AND 5

FROM LANE                  TO LANE
                      1       2      3

   1                  0      69      4     73
   2                 52       0     59    111
   3                  4      45      0     49

TOTALS               56     114     63    233
```

Manual Observer Inputs

```
EVENT COUNTERS

DEVICE CODE      NO HITS


    37             849
    38             126
    39               2
    40             138
    41               5
    42               1
    43             237
    44              41
    45            1387
    46             269
    47               2
    48             180
    49              13
    50              26
    51              77
    52               8
    53             510
    54              53
    55               0
    56              47
    57               1
    58              18
    59               8
    60               1
```

Figure 7 (Cont'd.). Several types of TES output.

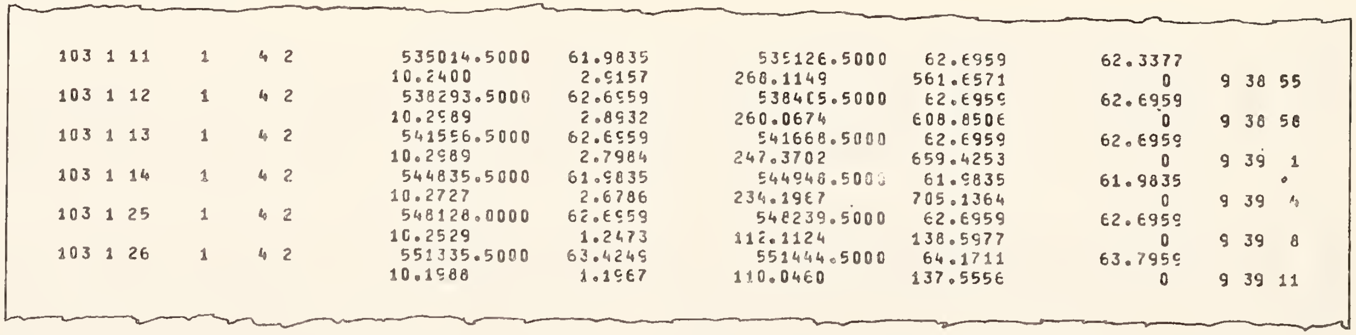
```
ABSOLUTE SPEED HISTOGRAMS (MPH)        LANE 1   TRAP 4         RANGE    0.0-100.0       INCREMENT   2.0

LOCAL/EXIT ----- SAMPLE SIZE    19         MEAN    56.42        STD DEVIATION   10.66

    0     0     0     0     0     0     0     0     0     0     0     0     0     0     1     0     0     0     1     1
    0     0     0     0     0     0     0     3     2     5     2     0     2     1     0     0     0     1     0     0
    0     0     0     0     0     0     0     0     0     0

LOCAL/THRU ----- SAMPLE SIZE  1480         MEAN    60.68        STD DEVIATION    5.47

    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     1     1     0     1     2
    2     3     5    10    23    32    51   113   159   253   244   217   147    95    65    28    17     7     4     0
    0     0     0     0     0     0     0     0     0     0

FORGN/EXIT ----- SAMPLE SIZE     5         MEAN    51.23        STD DEVIATION    7.85

    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     1
    0     0     1     0     0     0     1     1     0     0     1     0     0     0     0     0     0     0     0     0
    0     0     0     0     0     0     0     0     0     0

FORGN/THRU ----- SAMPLE SIZE   142         MEAN    59.67        STD DEVIATION    5.43

    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
    0     1     1     1     4     5     5    19    17    18    25    19    19     7     6     2     2     0     0     0
    0     0     0     0     0     0     0     0     0     0
-----------------------------------------------------------------------------------------------------------------------
RELATIVE SPEED HISTOGRAMS (MPH)        LANE 1   TRAP 4         RANGE  -50.0- 50.0       INCREMENT   2.0

LOCAL/EXIT ----- SAMPLE SIZE    19         MEAN     3.84        STD DEVIATION   10.05

    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     1     0
    0     0     0     4     2     0     5     4     1     0     0     0     0     0     0     0     0     0     1     0
    0     1     0     0     0     0     0     0     0     0

LOCAL/THRU ----- SAMPLE SIZE  1480         MEAN    -.17         STD DEVIATION    5.94

    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     3    13    18    19    38
   40    79   108   168   276   237   170   120    81    45    27    23     5     5     3     1     0     0     1     0
    0     0     0     0     0     0     0     0     0     0

FORGN/EXIT ----- SAMPLE SIZE     5         MEAN     9.77        STD DEVIATION   11.94

    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
    0     0     0     1     0     1     0     0     1     0     1     0     0     0     0     0     0     0     0     0
    1     0     0     0     0     0     0     0     0     0

FORGN/THRU ----- SAMPLE SIZE   142         MEAN      .62        STD DEVIATION    5.67

    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     1     0     1     0     3
    3     6    12    13    24    25    22    16     5     4     2     1     1     1     2     0     0     0     0     0
    0     0     0     0     0     0     0     0     0     0
```

Figure 7 (Cont'd.). Several types of TES output.

Tables are not complete. (The foreign subsample is not shown)

```
TIME  HEADWAY HISTOGRAMS (SEC)        LANE 1   TRAP 4         RANGE    0.0-  20.0      INCREMENT    .5

LOCAL/EXIT ----- SAMPLE SIZE    19        MEAN    5.90        STD DEVIATION    4.60

     0       2       3       1       1       0       0       0       2       1       0       2       1       0       0       0       1       0       1       0
     0       0       1       0       0       1       0       0       0       1       1       0       0       0       0       0       0       0       0       0


LOCAL/THRU ----- SAMPLE SIZE  1480        MEAN    4.96        STD DEVIATION    5.38

    47     193     179     127      93      89      72      61      63      48      51      38      43      34      39      26      21      26      26      23
    15      19      12       6      14      10      11       6       9       4       8       3       5       5       7       2       1       3       2      48

---------------------------------------------------------------------------------------------------------------------------------------------------

SPACE HEADWAY HISTOGRAMS (FT)         LANE 1   TRAP 4         RANGE    0.0-1500.0      INCREMENT  15.0

LOCAL/EXIT ----- SAMPLE SIZE    19        MEAN  532.92        STD DEVIATION  418.78

     0       0       0       1       0       0       1       3       0       0       0       2       0       0       0       0       0       0       0       0
     0       0       1       0       0       0       1       0       0       0       0       0       1       0       0       2       0       1       0       0
     0       0       0       0       0       0       0       0       1       0       0       0       0       0       0       0       1       0       0       0
     0       0       0       0       0       0       0       0       1       0       0       0       0       0       0       0       0       0       0       0
     1       0       0       0       0       1       0       0       0       1       0       0       0       0       0       0       0       0       0       0


LOCAL/THRU ----- SAMPLE SIZE  1480        MEAN  447.19        STD DEVIATION  493.21

     0      18      39      69      60      75      72      48      56      42      42      34      27      32      27      28      32      26      30      17
    25      25      29      17      20      16      15      18      23      17      13      20      12      10      12      19      10      16      13      11
    13      17      10      16       7       8      12       6      14       5       5       9       5       6       7       5      10       6       4      10
     4       1      11       2       7       5       5       5       4       0       5       1       5       2       3       9       2       6       2       2
     4       2       3       4       1       1       3       3       2       2       2       1       2       1       3       1       1       1       1      71
```

Figure 7 (Cont'd.) Several types of TES output.



```
103 1 11     1     4 2          535014.5000   61.9835          535126.5000   62.6959          62.3377
                               10.2400         2.9157         268.1149      561.6571               0     9 38 55
103 1 12     1     4 2          538293.5000   62.6559          538405.5000   62.6959          62.6959
                               10.2989         2.8932         260.0674      608.8506               0     9 38 58
103 1 13     1     4 2          541556.5000   62.6559          541668.5000   62.6959          62.6959
                               10.2989         2.7984         247.3702      659.4253               0     9 39  1
103 1 14     1     4 2          544835.5000   61.9835          544948.5000   61.9835          61.9835
                               10.2727         2.6786         234.1967      705.1364               0     9 39  4
103 1 25     1     4 2          548128.0000   62.6559          548239.5000   62.6959          62.6959
                               10.2529         1.2473         112.1124      138.5977               0     9 39  8
103 1 26     1     4 2          551335.5000   63.4249          551444.5000   64.1711          63.7959
                               10.1988         1.1967         110.0460      137.5556               0     9 39 11
```

The block of numbers shows data calculated for one vehicle as it traversed an array of paired sensors (tapeswitches). The sensors were deployed over 1500 feet in each lane of a three lane highway. Six pairs of sensors, each pair separated from adjacent pairs by 300 feet, were deployed in each lane.

The top line is read as follows:

Vehicle number 103 was a type 1 (auto) vehicle which entered the array in Lane 1 at detector pair 1.

This vehicle was in the first analysis period, the fourth platoon identified, and had 2 axles.

Continuing along the top row, the front axle arrived at the first sensor pair 535014.5000 milliseconds after data collection began. The speed of the front axle was 61.9835 miles per hour. The next two numbers (535126.5000 and 62.6959) are the time of arrival and speed for the rear axle. The last number in the row, 62.3377, is the average speed of both axles (calculated from raw data so this number is not necessarily the average of the front and rear axle speeds previously shown).

On the second line, 10.2400 is the wheelbase in feet. The vehicle was 2.9157 seconds or 268.1149 feet behind the nearest vehicle in the same lane. It was 561.6571 feet ahead of the nearest vehicle in the same lane. No manual code (0) was entered for the vehicle. The time of day was 9:38:55.

Successive paired rows present similar data as the vehicle traversed the remaining five paired sensors (or traps). It can be seen that vehicle 103 changed to Lane 2 between Traps 4 and 5. It exited the array at 9:39:11.

Figure 8. Individual vehicle record from the Traffic Evaluator System.

Since the information provided by the analysis program and illustrated in Figures 7 and 8 is too microscopic for the purposes of this study, additional software was developed to provide needed measures. However, the basic output was stored on tape so that more detailed analysis could be done where the global measures indicated a need. The parameters and format of the final output are described in Chapter V, *Measures of Effectiveness*. Detailed treatment of TES hardware and software will be found in Appendix A.

Time-Lapse Photography

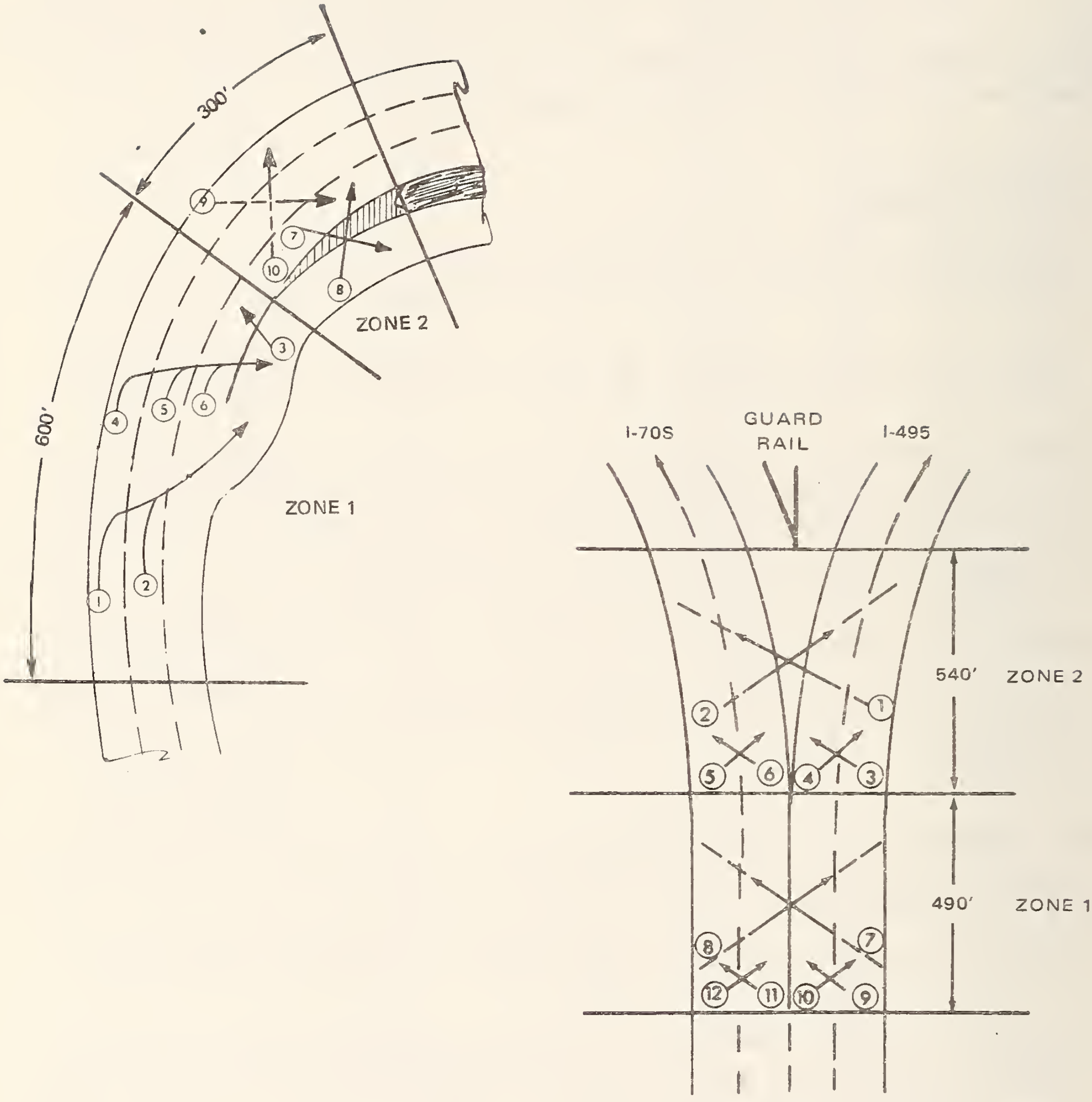
The processed film was projected and scored by human observers. Traffic volume, and, for gore sign locations, exit volume, were scored for each one-half hour film.

A variety of vehicle movements were then scored. All involved complete lane changes.

For gore sign locations, the highway was divided into two zones to more accurately pinpoint the area of road in which the driver made a lane changing maneuver. Each zone had specific characteristics which could generally be held constant over the several interchanges. As shown in Figure 9 on the following page, Zone 2 extended 300 feet downstream from the tip of the painted gore. Zone 1 extended 600 feet upstream from that point. This zone usually included the majority of the deceleration lane when such a lane was present. It will be noted that these zones correspond to TES tapeswitch placement (Traps 3, 4, 5, and 6), facilitating comparison between the frequency of lane change maneuvers as recorded by these two data collection methods.

Figure 9 illustrates six types of maneuvers (numbers 1, 2, 4, 5, 6 and 7, top drawing) scored for exiting vehicles and two maneuvers (numbers 3 and 8) scored for through vehicles. Also scored for through vehicles were "other" lane changes. These were lane changes which did not involve the exit ramp or deceleration lane. Examples in Zone 2 (numbers 9 and 10 are shown.

The gore at Interchange 17 northbound is configured significantly differently from the other interchanges and therefore the zones had to be selected differently. Scoring was limited to two zones; one for the painted gore (540 feet long), and one for the painted gore extension line (490 feet long). As shown in Figure 9, maneuvers in each direction across the painted gore and its extension line (Zones 2 and 1, maneuvers numbered 1, 2, 7 and 8, respectively) were scored, as were "other" lane changes. These were lane changes where the painted gore or its extension line was not crossed (e.g., maneuvers numbered 3 and 4). Maneuvers in each zone were tabulated separately.



INTERCHANGE 17 NORTH

Figure 9. Some of the types of lane changing maneuvers scored from the film at gore areas. All but Interchange 17 North were right exit interchanges and were scored similar to the top figure. Scoring at 17 North, a major fork left exit interchange was as shown in the bottom figure.

Highway geometrics are, of course, much simpler at the advance sign locations. It is realistic to distinguish only two zones; upstream and downstream from the advance sign locations. The 1500-foot Traffic Evaluator System tapeswitch array was placed symmetrically about the advance signs. The first and last switch pairs were positioned 750 feet upstream and 750 feet downstream, respectively, from the sign. The same distances were used to define the upstream and downstream zones in the camera films. However, the camera could not cover the full 1500 feet covered by the array and limitations in suitable camera locations determined whether the upstream or downstream zone was available for scoring. Where possible, lane changes were scored for the upstream zone; that is, from 750 feet in advance of the sign to the sign itself. Where this was not possible, the 750-foot downstream zone was scored. Lane changes toward the shoulder and toward the median were scored separately as were movements across more than one lane.

Film scoring was facilitated by use of the manual code boxes supplied with the Traffic Evaluator System. Devices containing eight read-out mechanical counters were built. Depression of one of the push buttons on the eight-button code box keyboard activated the equivalent mechanical counter. Figure 10 illustrates the use of these in scoring some of the vehicular movements at a gore. "Scoring patterns" were developed in which specific vehicle movements were assigned to particular keys on the keyboard. The keyboard is shown diagrammatically at the right of the figure. The numbered arrows show possible vehicle movements. The numbers themselves correspond to the keys on the code box keyboard.

The figure illustrates only one of the runs through the film. With this scoring pattern, the objective was to score movements of exiting vehicles or vehicles which nearly exit but at the last minute return to the through road (keys 3 and 8 in Figure 10). Another scoring run was then made and lane changes for nonexiting vehicles were scored. A different scoring pattern and different keyboard designations were used for this purpose. Depending upon the complexity of the interchange, more than one additional run through the film was often required to identify all movements in all zones. Thus, for a complex interchange gore site, as many as five runs through each film were required; two runs to score total and exit volumes and three runs to score different kinds of lane changes.

Questionnaire/Interviews

The questionnaire data were coded into a form suitable for keypunching and then transferred to punch cards. Table shells for basic descriptive statistics and key cross tabulations were prepared. From these, appropriate computer programs were developed and applied.[1]

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[1] We appreciate the contribution of Group Operations, Inc. and in particular of Mr. Jack Gleason of that organization. The actual programming and computer runs were done by Group Operations, Inc. under BioTechnology, Inc. direction.

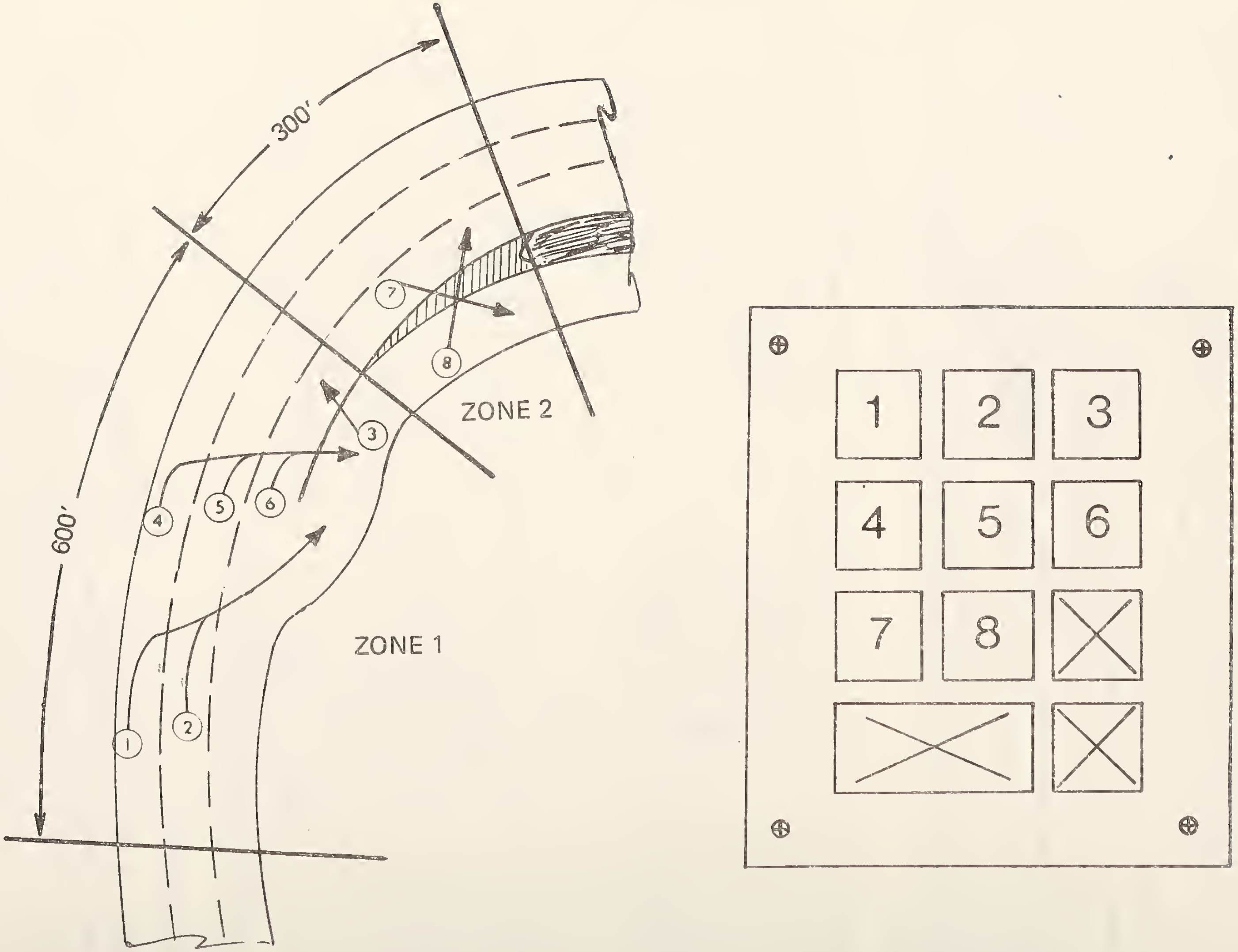

Figure 10. Zones and sample scoring pattern used in reducing film data. Numbers on maneuvers correspond to keyboard shown at right.

CHAPTER V

MEASURES OF EFFECTIVENESS

Two basic categories of effectiveness measures were employed. These were: (1) measures of motorist sign preference, and (2) measures of traffic performance.

Preference Measures

The preference measures were obtained from questionnaires distributed to the two classes of motorist respondents (thruput and exiting motorists). Two basic measures were obtained:

- respondent opinion as to the relative helpfulness of the two types of signs to the *average* motorist; and
- the personal preference of each respondent for the conventional or the diagrammatic signs.

Also, an open-ended question solicited comments by the respondents on the diagrammatic signs. Demographic and trip data were obtained on each respondent so that opinions and preferences for the two sign types could be examined relative to the length of trip the respondent was making, his familiarity with the route and similar characteristics.

Performance Measures

Most of the measures were of traffic and vehicle performance. These measures were obtained with the TES and/or time-lapse photography. The criteria used in selecting these measures were:

- the measures should be relatable to route negotiation difficulty, preferably through direct experimental evidence; and
- the measures should be relatable to accident likelihood, preferably on a quantitative basis.

Unfortunately, the literature suggests that valid measures of effectiveness meeting the above criteria is an area requiring further research. The best measures that could be defined fall into four categories: lane changing movements, lane placement, speed differences, and short headways.

Lane Changing Movements

Gore Locations. The incidence of erratic (unusual, hazardous, etc.) maneuvers was used as a measure. Such maneuvers are, of course, deviations from idealized paths defined from trace analysis for exiting and through vehicles. For example, the idealized path of a vehicle exiting at a right-hand exit is one in which the gore is approached in the right-most lane, the deceleration lane is entered promptly and the vehicle continues directly onto the exit ramp. In this study, deviations from this path have been termed gore weaves, weaves, high risk maneuvers, and risk maneuvers, the potential risk considered to increase as the location of the maneuver approaches the gore.

Through traffic may also perform erratic maneuvers. The "exit return" is a vehicle which starts to exit and then returns to the through traffic lanes.

Sets of erratic maneuvers must be defined differently at different interchanges because the theoretical path of the exiting and through traffic varies with interchange geometry. In this study, there were two basic types of interchange when categorized by the theoretical paths for exiting and through vehicles. All but Interchange 17 North fell into one category, typified by a right-hand single lane exit. Interchange 17 North is a left exit major fork. Figure 11 illustrates erratic maneuvers at these two types of interchanges. The most effective signing will be that associated with the lowest incidence of these maneuvers.

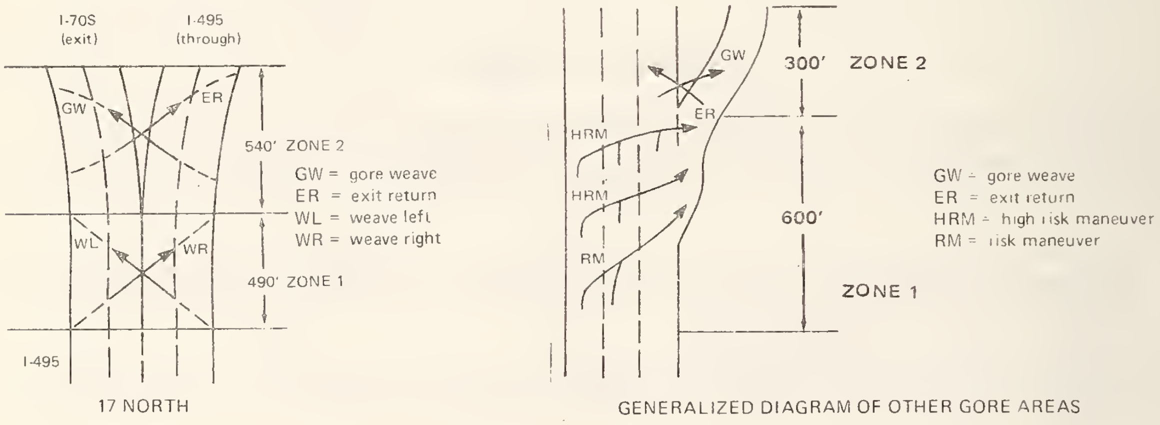

Figure 11. Diagrams of erratic maneuvers at two types of interchanges. The most effective signing will be that associated with the lowest incidence of the maneuvers defined above.

In reviewing erratic maneuver data, it is important to consider how the frequencies of maneuvers are calculated. When comparison is to be made *between* interchanges, maneuvers should be expressed per thousand through vehicles or per thousand exiting vehicles depending upon whether the vehicle does or does not exit. In this study, the proportion of traffic exiting ranged from about five percent (Interchange 15 North) to about 50 percent (Interchange 17 North). Because erratic maneuvers are frequently associated with exiting vehicles, the probability of such a maneuver is much higher at interchanges with larger proportions of exiting vehicles, other things being equal.

Several justifications are advanced for selecting unusual maneuver frequencies as effectiveness measures at gore areas. The first is their strong face validity. Drivers who are confused in negotiating an interchange might be expected to perform a last minute maneuver, either to exit or to continue through, at or very near the gore. This face validity is supported by the fact that these measures have been used by other investigators of signing effectiveness (for example, Hanscom, 1971; Roberts, 1971; Wyoming State Highway Department, undated).

Second, there is evidence of a relationship between accidents and the occurrence of traffic conflicts at intersections (Baker, undated; Perkins & Harris, 1967; Spicer, 1971). The applicability of this evidence must be tempered by the facts that traffic behavior at interchanges and intersections is very different and that a traffic conflict by definition requires two (or more) vehicles.

Finally, specific evidence linking performance of an unusual maneuver near the gore and driver difficulty negotiating an interchange was collected as part of this investigation. A special study was conducted over a two-day period (September 29 and 30, 1971). The location was the major fork, Interchange 17 North, where the left two of four lanes exit as I-70S, and the right two lanes continue as I-495. Vehicles were covertly observed from the Bradley Boulevard overpass just upstream from the gore. The observers identified and filmed three groups of vehicles:

- those which crossed the painted gore and exited onto I-70S
- those which crossed the painted gore extension line and exited onto I-70S
- those which did not change lanes and exited onto I-70S.

The first two of the above categories are unusual (erratic, hazardous) maneuver vehicles. It should be noted that there are channelization arrows painted on the road surface and that crossing either the painted gore or its extension line is a legal violation (although motorists are rarely if ever stopped for this violation).

Upon selecting a vehicle of interest, one of the observers described the vehicle by CB radio to a Maryland State Trooper located downstream on I-70S at a point not visible to the exiting vehicles and the Trooper flagged the vehicle down.[1,2] Another observer on the overpass noted the color and make of the selected vehicle and whether it was a straight through vehicle or one which crossed the painted gore or its extension line.

Once a vehicle was stopped, an interviewer located with the Maryland State Trooper noted the color and make of car and then asked the driver to complete a questionnaire. This questionnaire was the same one used on the thruput interview cases (see Appendix B). After the driver completed the questionnaire, two additional questions were asked and the answers recorded by the interviewer. These questions were:

A. Did you have a particular problem at the last interchange? (What?)

B. Did you take the right exit? (The answer to this question was established by the interviewer in discussion with the driver.)

Table 7 shows the number of drivers who did not change lanes ("Straight" in the table), who weaved across the painted gore extension line, or who weaved across the painted gore, and who responded that they either did or did not have difficulty negotiating the 17 North interchange. The total number of cases in the table is 97. A Chi-square test of these data is significant at the .05 level ($X^2 = 7.47$, df = 2).

Table 7

Relationship Between Vehicular Movement and Reports of Difficulty in Negotiating Interchange 17 North

VEHICLE MOVEMENT \ NEGOTIATION OF 17N	NO DIFFICULTY	DIFFICULTY
STRAIGHT	31	12
WEAVE ACROSS LINE	17	16
WEAVE ACROSS GORE	8	13

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[1] We are indebted to the Maryland State Police, Rockville, for their assistance on this study.

[2] Stopping vehicles on I-495 was prohibited but was allowed on I-70S. Thus, only vehicles exiting onto I-70S were studied.

In Table 7, drivers were classified as having no difficulty only if they answered Question A with such responses as "No," "None at all," etc. A variety of responses are included under the rubric "difficulty." These ranged from explanations of the need for a last minute maneuver because of traffic, to simply failing to paying attention, to confusion as to the proper route specifically attributed by the driver to the route guidance signing. Five of the drivers with difficulty, in fact, should not have exited onto I-70S given their intended destination (Question B).

It may be argued that all answers citing some form of difficulty should be included in the above test because (1) there is a tendency on the part of some people to attribute difficulty to an outside cause such as traffic or to a lesser cause such as inattention rather than driving related difficulty, (2) traffic was light, and (3) the advance and exit direction signs should have provided ample time for vehicles to position themselves before the gore was reached. However, for those who would prefer to exclude respondents who attributed their difficulty to inattention or to traffic, Table 8 is presented.

Table 8

Relationship Between Vehicular Movement and Reports of Difficulty in Negotiating Interchange 17 North (With "Difficulty" More Stringently Defined)

NEGOTIATION OF 17N / VEHICLE MOVEMENT	NO DIFFICULTY		DIFFICULTY	
STRAIGHT	31		5	
WEAVE ACROSS LINE	17	25	8	16
WEAVE ACROSS GORE	8		8	

Collapsing the two unusual maneuver categories because of the smaller numbers involved and applying the Chi-square test corrected for continuity, the data in Table 8 are significant at the .05 level ($X^2 = 4.90$, $df = 1$).

Reviewing the data in Tables 7 and 8, it is evident that as the movement of exiting vehicles shifts from a straight through path to an increasingly erratic path involving lane changes across the painted gore extension line and then across the gore itself, the proportion of drivers reporting difficulty in negotiating the interchange increases. The relationship is significant at the .05 level. Although a reasonably significant relationship was found, erratic maneuvers are only an imperfect indication of route negotiation difficulty. Some of those who did not perform erratic maneuvers still reported difficulty in negotiating the interchange and as many as half (depending upon the definition of difficulty) of those weaving across the gore reported no difficulty. Possible reasons for a less than perfect relationship include driving habits (some drivers may perform last minute lane changes by design; as a means of passing some slower moving exiting vehicles) and the inherent problems of subjective report (some drivers may not admit to route negotiation difficulty, even if they experienced some).

Advance and Exit Direction Sign Locations. At these locations, interest was primarily in the occurrence of maneuvers which might be related to eventual behavior at the gore. Two types of lane changing measures were defined: (1) the frequency of preparatory maneuvers, and (2) the frequency of through maneuvers. Each was expressed per thousand total traffic volume.

"Preparatory" signifies preparation for exiting. At all interchanges but 17 North, these were movements into the right-most lane. At 17 North, they were movements from one of the two right lanes into one of the two left lanes.

"Through" signifies maneuvers through vehicles might be expected to make to avoid the slower traffic frequently found in the lanes containing exiting traffic at gore areas. For all interchanges but 17 North, these are movements out of the right-most lanes. At 17 North, they are movements from one of the two left lanes to one of the two right lanes.

With more effective signing, an increase in these maneuvers should occur at advance and exit direction signs, accompanied by a decrease in erratic maneuvers at the gore. It should be noted, however, that the incidence of such maneuvers is undoubtedly a function of the proportions of through and exiting traffic. As effectiveness measures, they are particularly appropriate to Interchange 17 North where approximately half the traffic exits left onto I-70S, the other half continuing to the right on I-495. Even at this interchange, however, changes in preparatory and/or through maneuver frequencies at advance and/or exit direction signs was considered an ancillary measure of effectiveness. In other words, only if an increase in preparatory and/or through maneuvers at advance locations was accompanied by a decrease in erratic behavior at the gore was one type of signing judged more effective than the other.

Lane Placement

Lane placement means the proportion of vehicles in each lane as the decision point or exit ramp is approached. While lane changing movements were measured with both the TES and time-lapse films, detailed lane placement information could only be feasibly obtained with the TES.

Gore Locations. Vehicles were separated into two categories, those that exited and those that continued through. The proportions of vehicles at each trap in each lane were determined for each category. What is of interest in these data is the manner in which the exiting and through traffic were distributed as the exit ramp was approached and entered under the two signing conditions.

Figure 12 illustrates hypothetical data for exiting traffic at a right-exit interchange. Roman numerals refer to the TES traps at 300-foot intervals. The numbers beside the traps show the proportion of exiting vehicles crossing each trap. Because the sixth trap was always beyond the point where last minute maneuvers into and out of the exit ramp could be made, all exiting traffic must cross Trap 6 in the exit ramp.

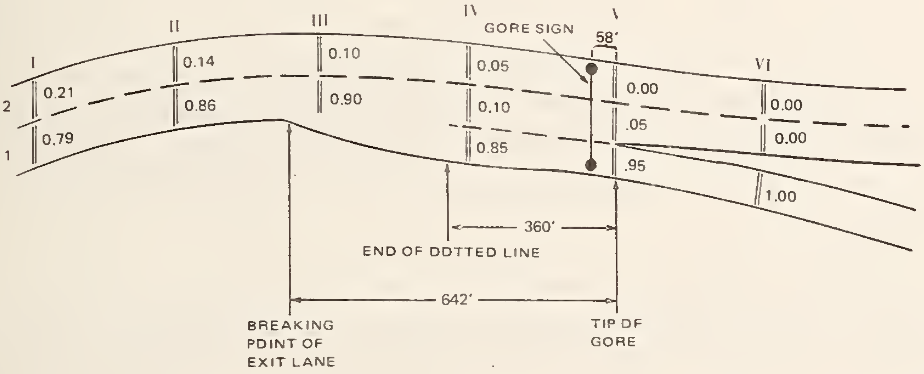

Figure 12. Hypothetical lane placement of exiting traffic under a specific signing condition.

As shown in Figure 12, 21 percent of the exiting traffic entered the array in Lane 2. A trace analysis of the theoretical path of exiting traffic suggests that this close to the exit ramp such traffic should be in Lane 1. At the gore itself (Trap 5), five percent of the exiting traffic is still in a through lane. These vehicles crossed the gore in the next 300 feet.

By this method of analysis, the most effective signing will be that providing a flow picture closest to the idealized path for exiting and through traffic.

Advance and Exit Direction Sign Locations. Similar flow pictures were developed at advance and exit direction sign locations. However, vehicles here were separated into four categories. Rather than exiting and through traffic, there were vehicles which did not change lanes, vehicles moving to the right, vehicles moving to the left and vehicles moving both left and right within the 1500-foot array.

Speed Differences

This measure was also obtained from TES data. It was computed as the proportion of vehicles traveling 5 mph or more *slower* than the mean speed for all vehicles. By this measure, the more effective signs were those producing the lowest proportion of vehicles meeting this 5 mph speed difference criterion.

This measure was derived from work by Cirillo (1968) and Solomon (1964) relating accidents and differences in speed from the mean speed on interstate highways and on main rural roads, respectively. Both investigators found that the relationship was fitted by a U-shaped curve. Minimum accident involvement occurred at approximately 12 mph above the mean speed on interstates (Cirillo, 1968) and at approximately 8 mph above the mean speed on main rural roads (Solomon, 1964). Accident involvement increased as speed departed from these minima in both directions. On interstates, the involvement rate doubled at 5 mph less than the mean speed. On main rural roads, the involvement rate doubled at 10 mph less than the mean speed. Further departures from the mean speed were accompanied by a sharp rise in the involvement rate.

Because this study of signing effectiveness was conducted on interstates, the Cirillo data were used. It should also be noted that her curve was developed for accidents occurring between 0900 and 1600 which is quite compatible with the 0930 to 1430 data collection interval used in this study. The measure was limited to speed differences of at least 5 mph below the mean, excluding those above, because slower moving vehicles are more likely to contain drivers reacting to the signing. This measure is compatible with cost-benefit analysis since vehicles meeting the criterion and accident likelihood can be related.

Headway Violations

Headway is the gap between the vehicle being counted and the immediately preceding vehicle. The TES provides such data in both space (feet) and time (seconds) dimensions. A "headway violation" was defined as a headway of one second or less. Proportions of vehicles meeting this criterion were obtained under the two signing conditions from TES data. A reduction in such violations would suggest a safer condition and more uniform traffic flow.

There is no direct evidence in the literature for a relation between headways of one second or less and route negotiation difficulty or accident likelihood. However, logic, driver education rules of thumb, and studies of gap acceptance and driver reaction time provide ample presumptive evidence of the relationship between short headway and accident likelihood. It has also been shown that the *minimum* spacing allowed by the average driver tailing another vehicle in the left lane of a four-lane highway, when converted to time is about 1.7 seconds in (Oglesby & Hewes, 1963).[1]

With regard to the relationship of short headways and signing, it must be remembered that driving is a time-sharing procedure. Therefore, signs which require more time for interpretation will decrease the time available for vehicle control. Either through a speed change (e.g., slowing to read the sign) or failure to devote adequate attention to gap maintenance with the preceding vehicle, a headway violation may result.

Data Analysis

Time-Lapse Photography. The various defined lane changing maneuvers were counted under the before and after signing conditions. The frequencies were expressed per thousand exiting, through or total vehicles as appropriate.

The more effective signing will be that associated with the lowest frequencies of hazardous maneuvers (gore weaves, exit returns, etc.) at the gore. An ancillary measure is an accompanying increase in preparatory and/or through maneuvers at advance and/or exit direction signs.

Traffic Evaluator System. Vehicles performing hazardous maneuvers and/or meeting the criteria for speed differences or headway violations were counted under the diagrammatic and conventional signing conditions. Software was developed to provide not only the proportions but also the 95 percent confidence limits on the proportions. Emphasis was placed on proportions rather than on continuous variables, such as changes in average speed, because significant changes in proportions can be related to safety and accidents. Thus, they are compatible with cost-benefit analyses of the two types of signs.

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[1] In addition, the British design standard has been set at 1.0 seconds of headway. Personal communication, H. A. J. Prentice, Transport and Road Research Laboratory, Crowthorne, Berks, England.

The reason for using confidence limits was threefold. First, they provide the interval within which the true proportion lies. Second, they could be generated as the data were collected, rather than performing an additional analysis of before and after data such as would be required if significance tests were being done directly. Third, confidence limits can be used to perform significance tests in a straightforward fashion as will be described shortly.

In order to compare the relative effectiveness of the conventional and diagrammatic signs, TES output data were summarized in four basic types of tables; two for advance and exit direction signs and two for gore signs.

Table 9 is a typical output table for traffic at the advance sign for a right-hand exit. It has two parts, separated by the dashed line. The top part shows the proportion of autos, nonautos, and all vehicles performing various kinds of maneuvers. "Preparatory" maneuvers and "through" maneuvers have been defined previously. Proportions in the table within a given column above (or below) the dashed line sum to one. The pairs of numbers in each cell show the proportions (top number) and the 95 percent confidence limits for each proportion (bottom number). From the table it can be seen that the proportion of autos which proceeded through the entire 1500-foot tapeswitch array without changing lanes at this advance sign was .79045 while the proportion of nonautos was .86590. It will be noted that the intervals (plus and minus the 95 percent confidence limit for each proportion) on the two proportions do not overlap. The interval for autos is .78141 to .79949 whereas for nonautos it is .84319 to .88861.

Signficance Testing. Case 1. It can be shown mathematically that when the 95 percent confidence intervals do not overlap, the proportions *are* significantly different using the z test at the .05 level or better. Where the intervals do overlap, there are two situations. *Case 2.* If either (or both) proportions fall within the confidence interval defined for the other, the proportions are *not* significantly different at the 0.5 level. *Case 3.* When the intervals overlap and neither proportion falls within the interval established for the other proportion, a z test must be performed. This can be simply done from the data in the tables if we accept the .05 level of significance. The tables provide the 95 percent confidence limits. It can be shown mathematically that if the difference between the proportions is greater than the square root of the summed squares of the confidence limits, then the proportions are significantly different at the .05 level (or better). In other words,

$$\text{if } \left|\text{proportion A} - \text{proportion B}\right| \geqq \sqrt{\text{Conf. Limit}_A^2 + \text{Conf. Limit}_B^2}$$

then, proportions A and B are significantly different at the .05 level or better.

Table 9

Illustrative Table Typical of Those Prepared for Advance and Exit Direction Sign Locations

INTERCHANGE 16 SOUTH
ADVANCE (G-2) SIGN (AFTER)
4/20/72
0945-1430

	AUTOS		NONAUTOS	ALL	
	7788		865	8653	Sample Size
1. PREP. MANUEVERS	.04327 .00452	①	.02428 .01026	.04137 .00420	Proportion
2. THROUGH MANUEVERS	.10901 .00692	①	.07977 .01806	.10609 .00549	95% Confidence Limit on Proportion
3. OTHER LANE CHANGES	.05727 .00516	①	.03006 .01138	.05455 .00478	
4. NO LANE CHANGES	.79045 .00904	①	.86590 .02271	.79799 .00846	The Sets of Proportions in Each Column Above and Below this Line Sum to 1.00000
1. SPEED DIFFERENCE	.20467 .00896	①	.34220 .03162	.21842 .00871	
2. HEADWAY VIOLATION	.12018 .00722	①	.08786 .01887	.11595 .00677	
3. DBL LANE CHANGES	.00719 .00188	①	.00116 .00226	.00659 .00170	
4. 1 + 2	.07203 .00574	②	.06936 .01693	.07177 .00544	
5. 2 + 3	.00462 .00151		0.00000 0.00000	.00416 .00136	
6. 1 + 3	.00372 .00135		0.00000 0.00000	.00335 .00122	
7. 1 + 2 + 3	.00270 .00115	②	.00231 .00320	.00266 .00108	
8. NORMAL	.58487 .01094	①	.49711 .03332	.57610 .01041	

Notes:

Preparatory Maneuvers	— Movements into the right-most lane except at 17 North where they are movements into one of the two left lanes from one of the two right lanes.
Through Maneuvers	— Movements out of the right-most lane except at 17 North where they are movements into one of the two right lanes from one of the two left lanes.
Speed Difference	— Vehicles traveling at least 5 mph less than the mean speed.
Headway Violation	— Headway of 1 second or less.
DBL Lane Changes	— Double lane changes. Moves across more than one lane within 300 feet.
① or ② or ③	— Case 1 or 2 or 3 for significance testing.
———————	— Significant difference at the .05 level or better between the numbers joined. For comparison between tables, an arrow (↑ or ↓) indicates a significant difference between the value so marked and the value of the same variable under the conventional signing condition (see Results). The direction of the arrow indicates the direction of change (e.g., ↑ indicates a significant increase was found in the diagrammatic signing condition).

Beneath the dashed line in Table 9 are shown the proportions of autos, nonautos and all vehicles that met each of the threshold criteria previously defined; namely, speed differences, headway violations, and, at advance signs, double lane changes. Double lane changes are vehicles which shifted more than one lane within 300 feet.

Table 9 shows that when autos and nonautos are compared, there are eight significant differences. All are Case 1 situations for significance testing. Of interest is the last row in Table 9 which shows the proportions of vehicles meeting *none* of the criteria listed (below the dashed line) or combinations of them. A significantly larger proportion of autos fell into this category of NORMAL than did nonautos. This is not surprising because many more nonautos violated the 5 mph-less-than-the-mean-speed criterion than did autos, which might be expected.

Table 10 has been prepared for the gore location of the same interchange but shows an alternate stratification. Local vs. foreign (i.e., license plates other than Maryland, Virginia or the District of Columbia) vehicles are separated rather than autos and nonautos. Proportions above the dashed line sum to one. Significantly more foreign vehicles than local vehicles violated the speed difference criterion but significantly fewer violated the headway criterion. In terms of the number of vehicles falling into the normal category, foreign and local vehicles were not significantly different. Double lane changes (movements across more than one lane within 300 feet) are shown separately below the dashed line.

Tables similar to Table 9 (for advance and exit direction locations) and Table 10 (for gore locations) were prepared under the conventional and diagrammatic signing conditions. Comparison across signing conditions is done in the same way as has been illustrated within the tables. In the Before/After study, the most effective signing is that associated with the lowest proportions of vehicles showing speed differences, headway violations, hazardous maneuvers or combinations of these or with the highest proportion of "normal" vehicles. In the Acclimation phase, foreign vehicles should show an improvement in performance by these same measures on the day after the signs are changed if the diagrammatics are more effective. However, local vehicles may show a performance decrement if the sign change results in a novelty or startle effect.

An influence on behavior at the gore is considered more important than behavior at advance or exit direction signs. An increase in preparatory or through movements at these locations is not considered significant unless performance at the gore also improves.

Table 10

Illustrative Table Typical of Those Prepared for Gore Sign Locations

INTERCHANGE 16 SOUTH
GORE SIGN (AFTER)
5/11/72
0945-1430

		LOCAL		FOREIGN	ALL	
		1738		248	1986	Sample Size
1.	SPEED DIFFERENCE	.16226 .01733	③	.21774 .05137	.16918 .01649	Proportion
2.	HEADWAY VIOLATION	.10932 .01467	①	.04939 .02671	.10171 .01329	95% Confidence Limit on Proportion
3.	HAZARDOUS MANEUVERS	.00863 .00435	②	.00805 .01113	.00856 .00405	
4.	1 + 2	.05121 .01036	②	.03629 .02328	.04935 .00953	
5.	2 + 3	.00230 .00225		0.00000 0.00000	.00201 .00197	
6.	1 + 3	.00460 .00318		0.00000 0.00000	.00403 .00279	
7.	1 + 2 + 3	.00230 .00225	②	.00403 .00789	.00252 .00220	
8.	NORMAL	.65938 .02228	②	.63548 .05779	.66264 .02079	Proportions Above Dashed Line Sum to 1.00000
9.	DBL LANE CHANGES	.01323 .00537	②	.01210 .01361	.01309 .00500	

Notes:

Speed Difference	— Vehicles traveling at least 5 mph less than the mean speed.
Headway Violation	— Headway of 1 second or less.
Hazardous Maneuvers	— Gore weaves, exit returns, high risk and risk maneuvers (or moves across the painted gore or its extension line at Interchange 17 North).
DBL Lane Changes	— Double lane changes. Moves across more than one lane within 300 feet.
① or ② or ③	— Case 1 or 2 or 3 for significance testing.
————	— Significant difference at the .05 level or better between the numbers joined. For comparison between tables, an arrow (↑ or ↓) indicates a significant difference between the value so marked and the value of the same variable under the conventional signing condition (see Results). The direction of the arrow indicates the direction of change (e.g., ↑ indicates a significant increase was found in the diagrammatic signing condition).

Table 11 illustrates a lane placement table. At gore areas, similar tables are provided for exiting (Table 11) and through traffic (not illustrated). At exit direction and advance sign locations, data are provided on four subpopulations: traffic which did not change lanes, traffic which changed lanes toward the shoulder, traffic which changed lanes toward the median and traffic which made lane changes in both directions within the 1500-foot array. The basic format for all tables is similar to that in Table 11. The right half of each table shows the proportion of vehicles crossing each trap in each lane as the traffic moves downstream. Illustrative diagrams are provided above. The left side of each table breaks down the proportions crossing each trap in each lane into subproportions. The subproportions show the proportions of vehicles with headway violations (HV), speed differences (LS—for low speed), both (HV + LS) and neither (N). Use of these data to evaluate signing effectiveness in terms of idealized traces has already been described. For example, more effective signing will be associated with a larger proportion of *exiting* vehicles entering the gore area for a right exit in the right-most lane.

Table 11

Illustrative Table of Lane Placement for Exiting Traffic. The Diagram Portrays the Total Proportions of Exiting Vehicles Striking Each Trap in Each Lane Without Regard to Speed Differences and Headway Violations. These Data are Shown in the Smaller Right-Hand Table Beneath the Diagram

INTERCHANGE 16 SOUTH
GORE SIGN (AFTER)
5/11/72
0945-1430

EXIT TRAFFIC — Stratification
1933 — Sample Size

Lane 1. Lane Numbers are Keyed to Diagram at Right.

	TRAP 1	2	3	4	5	6
① N	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.7227 .0200	.7517 .0193
① HV	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.0538 .0101	.0554 .0102
① LS	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.1536 .0161	.1578 .0163
① HV+LS	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.0357 .0093	.0352 .0082
2 N	.6368 .0214	.6461 .0213	.6503 .0213	.6420 .0214	.0114 .0047	0.0000 0.0000
2 HV	.0621 .0108	.0683 .0112	.0709 .0114	.0652 .0110	0.0000 0.0000	0.0000 0.0000
2 LS	.1438 .0156	.1459 .0157	.1671 .0166	.2095 .0181	.0072 .0038	0.0000 0.0000
2 HV+LS	.0388 .0086	.0388 .0086	.0435 .0091	.0528 .0100	.0005 .0010	0.0000 0.0000
3 N	.0704 .0114	.0636 .0109	.0435 .0091	.0197 .0062	.0039 .0044	0.0000 0.0000
3 HV	.0129 .0050	.0093 .0043	.0031 .0025	.0005 .0010	.0010 .0014	0.0000 0.0000
3 LS	.0119 .0048	.0109 .0046	.0093 .0043	.0036 .0027	.0010 .0014	0.0000 0.0000
3 HV+LS	.0016 .0018	.0016 .0018	.0016 .0018	.0005 .0010	.0005 .0010	0.0000 0.0000
4 N	.0155 .0055	.0098 .0044	.0072 .0038	.0047 .0030	.0021 .0020	0.0000 0.0000
4 HV	.0031 .0025	.0026 .0023	.0021 .0020	.0010 .0014	.0005 .0010	0.0000 0.0000
4 LS	.0026 .0023	.0031 .0025	.0010 .0014	.0005 .0010	0.0000 0.0000	0.0000 0.0000
4 HV+LS	.0005 .0010	0.0000 0.0000	.0005 .0010	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

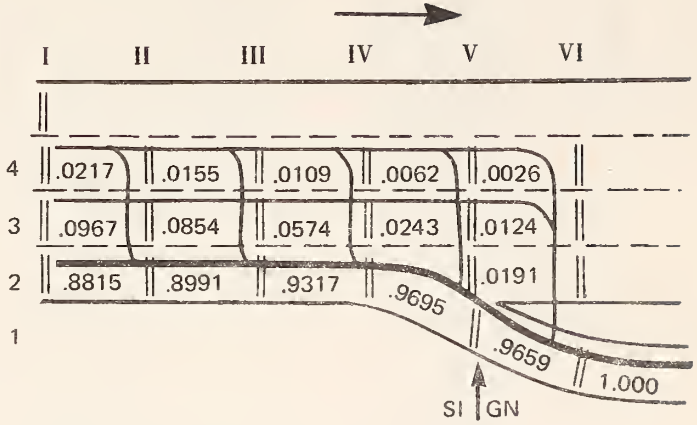
Notes:

HV — Headway violation (headway of 1 second or less).

LS — Low speed (identical to speed difference. Vehicles traveling at least 5 mph less than the mean speed).

N — Vehicles without headway violations or speed differences.

1, 2, 3, 4 — As row headings indicate lane.



TOTALS LANE 1	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.9659 .0081	1.0000 0.0000
TOTALS LANE 2	.8815 .0144	.8991 .0134	.9317 .0112	.9695 .0077	.0191 .0061	0.0000 0.0000
TOTALS LANE 3	.0967 .0132	.0854 .0125	.0574 .0104	.0243 .0069	.0124 .0049	0.0000 0.0000
TOTALS LANE 4	.0217 .0065	.0155 .0055	.0109 .0046	.0062 .0035	.0026 .0023	0.0000 0.0000

CHAPTER VI

RESULTS

This Chapter is divided into two major parts. The first part describes the results of the main Before/After study. The second part describes the results of the Acclimation phase study. Chapter VII discusses sources of error. The last Chapter in this Part, Chapter VIII, summarizes the overall results of the I-495/I-70S field study.

Before/After Study

Performance Measures

Motorist performance data derived from the Traffic Evaluator System and time-lapse photography are presented first. These results are categorized by interchange. It will be remembered that the TES was used at 14 of the 22 signing locations while the camera was used at all locations. However, where TES data are available, only data derived from this data collection tool are presented. At sites where TES data were not available, data derived from the time-lapse films are reported. Time constraints prevented compiling overlapping results from the two data collection tools except where necessary (i.e., evaluation of the validity of TES data, see Chapter VII, and at locations where technical difficulties prevented use of TES data).

After presentation of the performance measures employed in the Before/After study, the results of the questionnaire survey of motorists are presented. In general, these results are relevant to the study as a whole, rather than to particular interchanges.

A strict format is followed in reporting the results of the Before/After study. Within each interchange, results at gore locations are presented first, followed by results at the exit direction location and ending with results at the advance sign. The reason for this order is that unless significant differences are found at gore areas, any significant differences at exit direction and advance sign locations are considered ancillary. Where significant differences in behavior at the gore are found, data at the advance and exit direction locations frequently allow tracing back the changes seen at the gore to changes in behavior at earlier signing locations.

Concerning the data collected with the TES, several comments are in order. First, detailed presentation of vehicular velocity information is restricted to gore areas. Data on the days when manual coding was done is presented so that speeds of local vehicles, nonlocal vehicles and the population as a whole can be compared. Appropriate comments are made about the other days.

It will be noted that sample sizes for local and nonlocal vehicles in the tables sum to less than the total for all vehicles. This is because 15 minute breaks were taken during the total data collection interval. Subtracting the time allotted to breaks, manual coding occupied 3½ of the five hour data collection interval. The TES continued to record data during the break period, however. Thus, local and nonlocal vehicle populations represent 3½ hours of data whereas the data for all or total vehicles represent five hours.

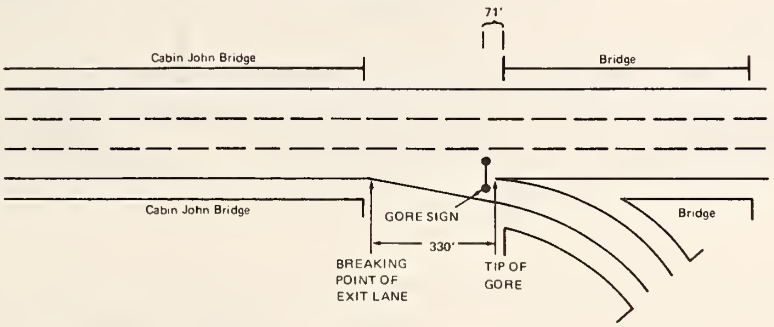
A great deal of the information collected with the TES in the course of this study is not presented in this report. Additional data on speeds, volumes and a number of defined maneuvers exist in hard copy form. A great deal of further information is stored on magnetic tape. Such information includes tracks of all vehicles through the array (in the order of one-half million vehicles) and tabular frequency distributions of absolute speed, relative speed, time headway, space headway and summary tables of various types. Interested individuals should contact the Program Manager, Dr. Truman Mast, Office of Research, Federal Highway Administration, for further information.

Finally, a word of encouragement to the reader contemplating the bulk of this section is appropriate. Much of the TES data are presented in tabular form. However, the tables are annotated on the same page. The annotations point out highlights of the table. It is quite feasible to read the annotations and refer to the illustrations only. On the other hand, those wishing to delve more deeply may study the tables. Where the results of significance tests are not indicated in the tables, the methods described in Chapter V may be used to assess significance levels directly from the tabular data.

Interchange 15 North

A single right-hand off ramp is provided for northbound motorists exiting at Interchange 15. The exit is located just beyond the Cabin John Bridge which spans the Potomac River. Sight distance to the gore is good. As shown in the schematic diagram of the highway in the vicinity of the gore, there is no deceleration lane.

Exit 15N Gore



The only route guidance signing is an exit sign at the gore. Unlike all other interchanges studied, upstream signing in the form of an advance sign and an exit direction sign is not provided.

The results reported were collected by means of time-lapse photography[1].

Average hourly volume at this interchange in 1971 was 2096, with an average of 5.0 percent exiting. In 1972, hourly volume had increased to an average of 2134, with 5.5 percent exiting.

For scoring purposes, this interchange was divided into two zones. Zone 2 extended from the cement barrier in the gore and extended 300 feet upstream. Zone 1 began at this point and extended another 600 feet upstream. Thus, the total scoring area extended 900 feet upstream from the physical gore. The maneuvers scored are shown with Figure 13 which also portrays the results.

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[1] The scoring of time-lapse films in the course of this project occupied considerable time and effort to which a number of people contributed; notably Jane Burnette, Margaret Forsythe, Chris Nerone and Gerald Vallette. Particular thanks are due to Margaret Forsythe and Jane Burnette. Ms. Forsythe formalized the scoring procedure so that the task could be accomplished efficiently. She also contributed extensively to the scoring effort. Ms. Burnette performed the analysis of the film data and compiled the results.

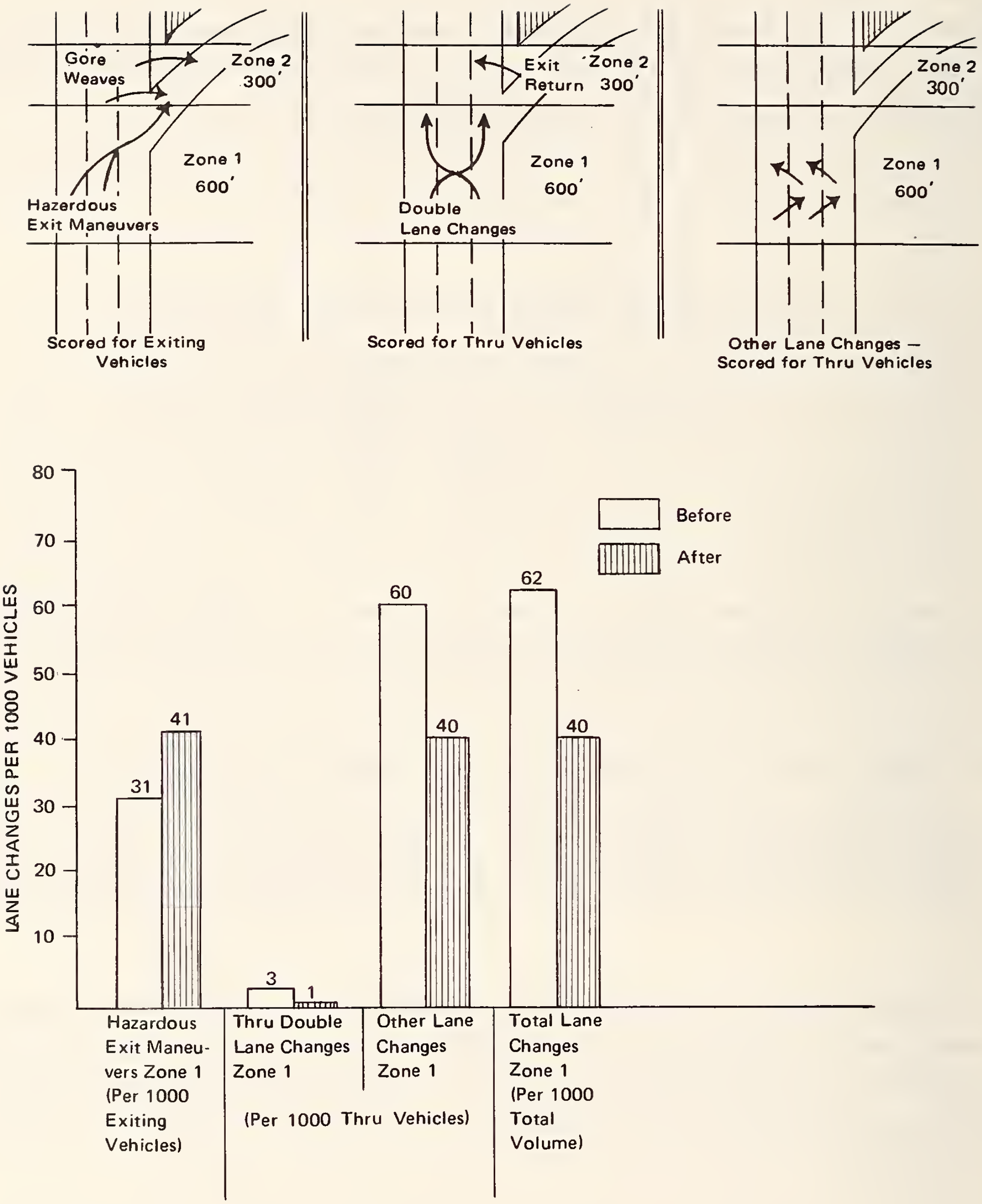


Figure 13. Lane changes at 15 North gore.

There were very few gore weaves at this interchange, and no exit returns.

Measures for Zone 1 show an increase in hazardous exit maneuvers but this increase is not significant (z = .48). These maneuvers averaged 31 per thousand exiting vehicles under conditions of conventional signing as compared to 41 per thousand under diagrammatic signing. Through double lane changes showed a decrease from an average of three per thousand through vehicles Before to one per thousand After. The actual frequency counted from the films was 13 in the Before phase, four in the After phase.

Other lane changes decreased significantly, from an average of 60 per thousand through vehicles Before to 40 per thousand After. This difference is significant at the .01 level (z = 4.26). Total lane changes per thousand total volume also showed a significant decrease (.01 level, z = 4.60), with averages of 62 Before and 40 After.

In summary, the incidence of erratic maneuvers (gore weaves, exit returns, hazardous exiting maneuvers) provides no evidence of a significant change in behavior at this interchange associated with the change in signing.

Interchange 16 North

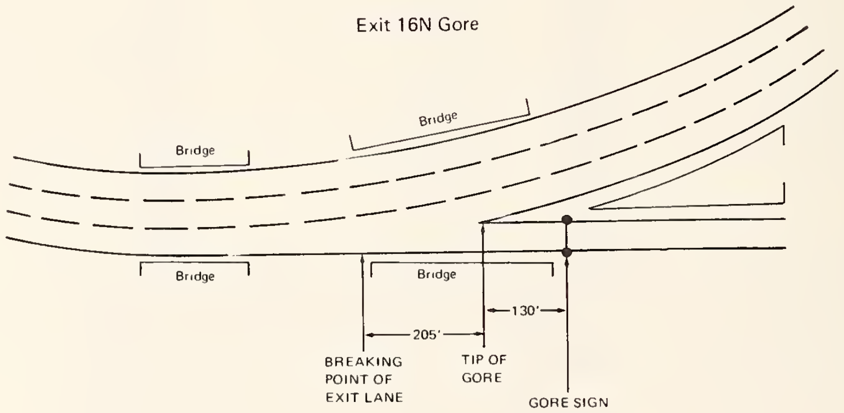
The approach to the exit ramp is signed with an advance, exit direction and gore sign. The gore is approached on a descending slope; thus, sight distance is good.

The exit is a tangential off ramp which leads onto a collector-distributor. The exiting motorist faces potential conflict in the collector-distributor at the merge point with Cabin John Parkway traffic. However, such traffic from the Parkway is very light.

From the collector-distributor, the motorist may select secondary ramps leading to River Road East or River Road West. A sign in the collector-distributor to this effect is located at the first secondary ramp. This sign, the sign at the exit ramp from I-495, and the exit direction and advance signs were included in this study.

Results at the gore and in the collector-distributor are presented first. Then, working upstream from the exit ramp, results at the exit direction and at the advance sign are described. All data reported were collected with the time-lapse filming technique.

Gore and Collector-Distributor. A schematic diagram of the gore area is shown below. The tangential off ramp requires that the motorist make a positive steering action to the left to continue on the through traffic lanes. Failure to do so will result in exiting at this ramp.



Hourly volume on the approach to the exit ramp averaged 1796 in 1971. The percentage of vehicles exiting averaged 13.0. In 1972, hourly volume averaged 1936, with 13.3 percent exiting.

Two zones were scored in the vicinity of the gore. The zones were similar to those scored at Interchange 15 North. As was found at that interchange, there were very few gore weaves or exit returns (one or two per thousand vehicles) (see Figure 14).

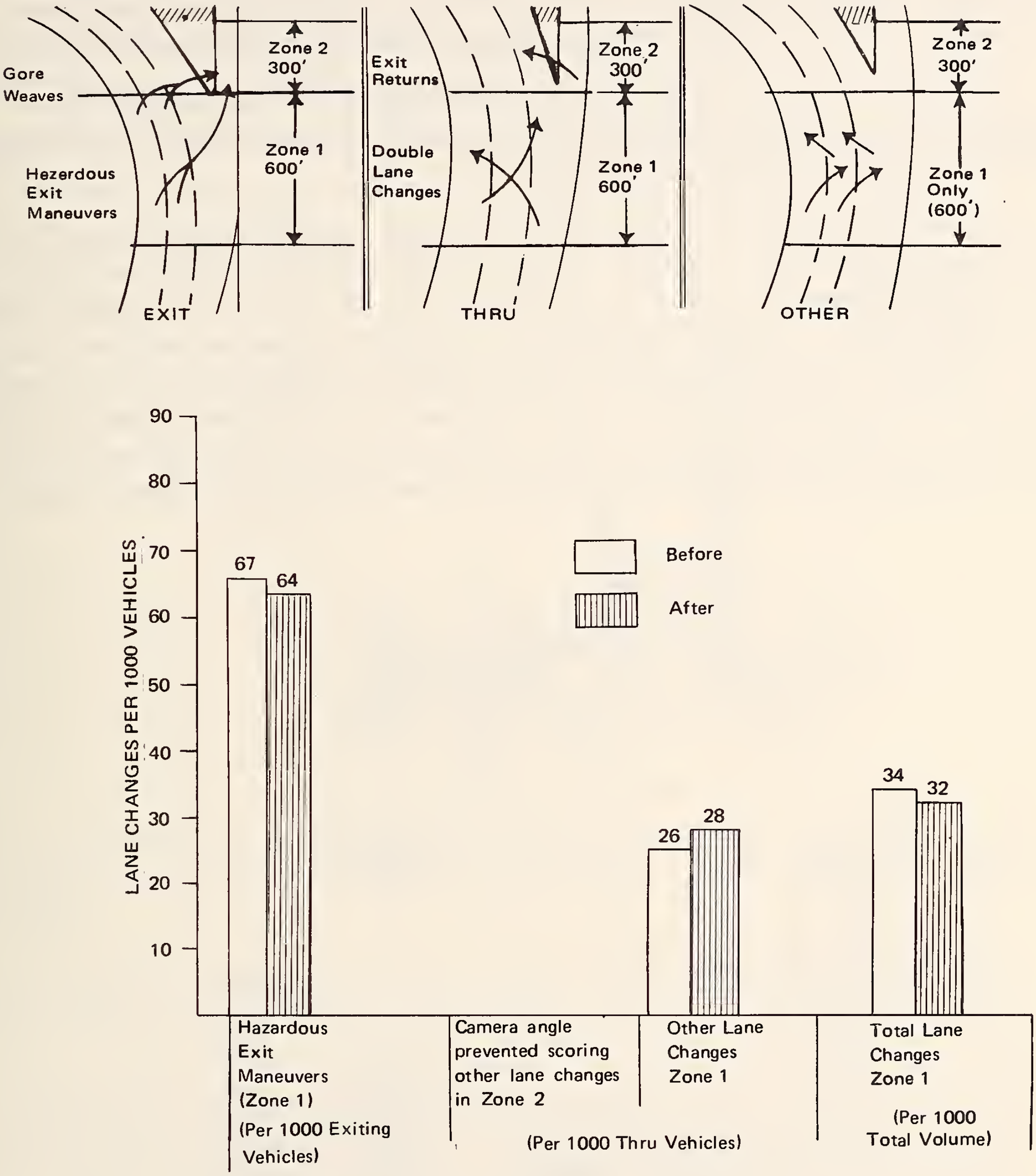
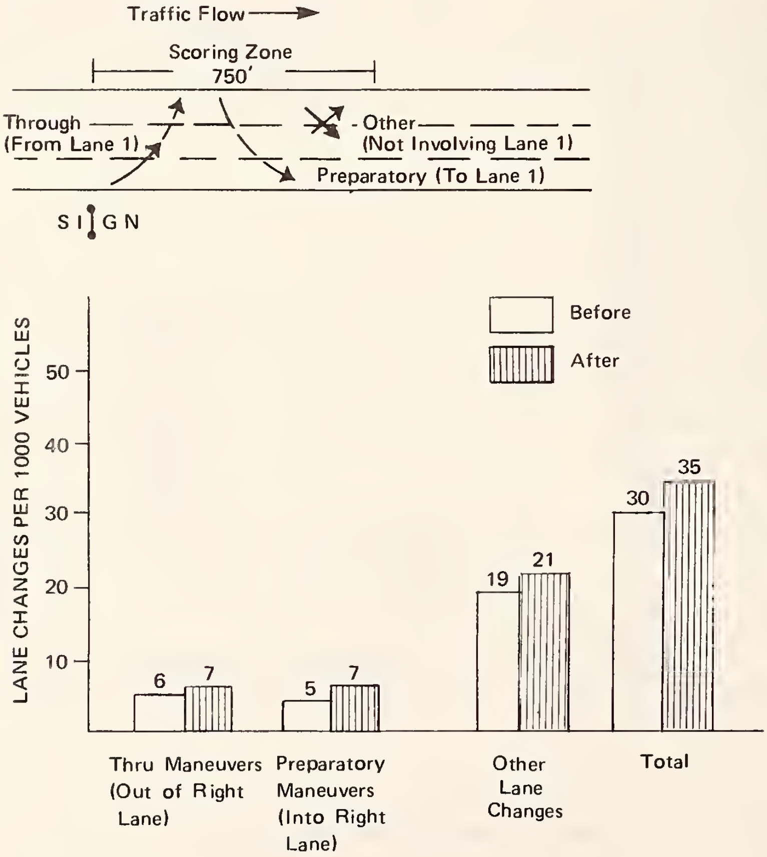


Figure 14. Lane changes at 16 North gore.

In Zone 1, there was a slight decline in hazardous exit maneuvers (exits from any lane other than Lane 1). These maneuvers averaged 67 per thousand exiting vehicles in 1971 and 64 per thousand in 1972 (an insignificant difference, z = .22). Other lane changes in this zone increased from an average of 26 per thousand through vehicles Before to 28 per thousand After, also an insignificant difference (z = .56). Total lane changes also showed insignificant differences (z = .53), with averages of 34 per thousand total volume Before and 32 After.

In the collector-distributor, the gore at the merge point between exiting traffic from I-495 and Cabin John Parkway traffic was studied. However, very few weaves across this gore were found in either the Before or After study.

Exit Direction (G-1) Sign. At this location, the scoring zone began at the sign and encompassed the area downstream 750 feet. Lane changes in all categories increased, but none of these increases was significant. Through maneuvers (maneuvers out of the right lane to Lanes 2 or 3) averaged six per thousand total volume in the Before phase and seven per thousand After. Preparatory maneuvers (maneuvers into the right lane from Lanes 2 or 3) averaged five per thousand total Before and seven per thousand After. Other lane changes increased from 19 to 21. Total lane changes therefore showed an increase from 30 per thousand total volume under conventional signing to 35 per thousand under diagrammatic signs.

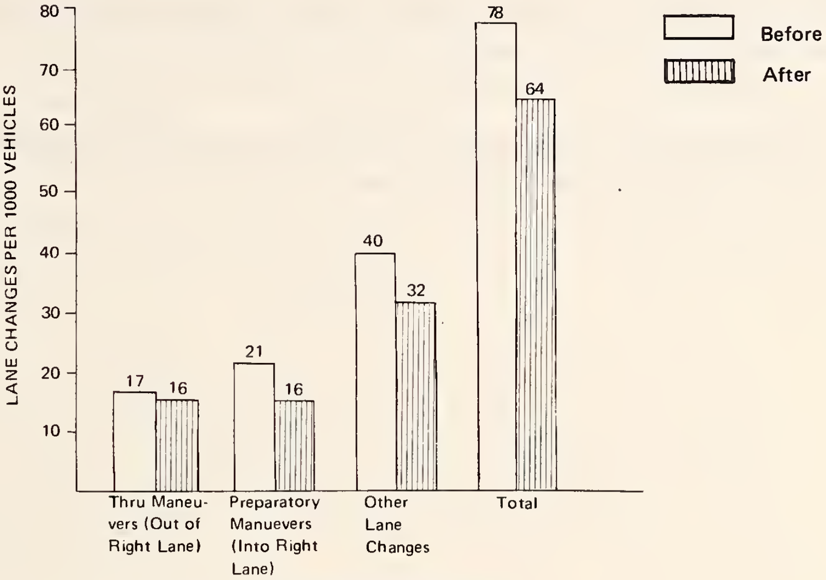


LANE CHANGES AT INTERCHANGE 16 NORTH: G-1

Advance (G-2) Sign. The same maneuvers were scored as at the G-1 location. However, the scoring zone (a function of suitable camera locations) extended 500 feet upstream from the sign to the sign itself.

Through maneuvers showed almost no difference under diagrammatic signing. Average through lane changes per thousand total volume numbered 17 under conventional signs and 16 under diagrammatics. This is an insignificant difference (z = .27).

Preparatory maneuvers showed a decline from 21 per thousand total volume in the Before phase to 16 per thousand After. This is also an insignificant difference (z = 1.71).



LANE CHANGES AT INTERCHANGE 16 NORTH: G-2

Other maneuvers showed a decline which was significant at the .05 level (z = 2.02). The Before phase averaged 40 lane changes per thousand total volume as compared to 32 in the After phase.

The total decline was also significant (z = 2.48, $p < .05$). The average lane changes per thousand total volume was 78 Before and 64 After.

Summary. Time-lapse film data were collected at the gore and at exit direction and advance sign locations of Interchange 16 North. No significant impact of the change in signs on traffic behavior was found when measured in terms of hazardous maneuvers of exiting or through traffic at the gore. There was also no significant effect of the signs on the proportion of vehicles moving into or out of the right lane at advance or exit direction locations; movements which have been described as preparatory or through on the basis of their relationship to hypothesized behavior at the gore.

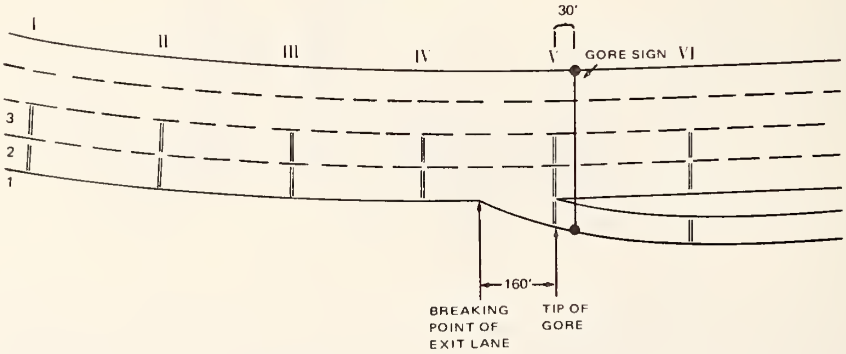
Interchange 16 South

This is a complex interchange with some cloverleaf characteristics. The approach is four lanes wide and signed with advance and exit direction signs. At the first gore, the motorist exits onto a collector-distributor. Through traffic shortly encounters a second gore. At this gore, the right lane continues as the exit ramp and is dropped from the through traffic lanes.

Data were collected by means of the TES at the first gore and by time-lapse films at the other three locations. Results at the first gore are presented first, followed by results at the second gore, at the exit direction location and at the advance sign.

First Gore (Washington-Potomac; River Road). Tapeswitch instrumentation at this gore is diagrammed below. Because of restrictions on the total inputs which could be accommodated by the TES, tapeswitches were deployed only in the two right lanes and in the exit ramp. The two through lanes instrumented are labelled Lanes 2 and 3 from the shoulder towards the median while the exit ramp is labelled Lane 1.

Exit 16S Gore



The range in percentage hourly volume using each lane (measured at Trap 6) for exiting and through traffic collected over the four days (two in the Before phase, two in the After phase) was as shown below:

Range In Percentage Hourly Volume

		Total	Auto	Nonauto
Lane 1	(Exiting)	34-36	35-37	25-34
Lane 2	(Through)	20-22	21-23	5-13
Lane 3	(Through)	43-45	40-43	60-64

About 35 percent of the automobile traffic entering the array in Lanes 2 or 3 exited. The nonauto traffic was more variable. The range in Lanes 1 and 2 is wide because of differences in the Before and After phases. In the Before phase, 25 percent of the nonauto traffic entered Lane 1 (that is, exited), while in the After phase, 31 to 34 percent did so. In the Before phase, 11 to 13 percent of the nonauto traffic was recorded at Trap 6 in Lane 2 whereas in the After phase, the percentage was five to six percent. The proportion of nonauto traffic in Lane 3 was about the same in the Before and After phases. The proportion of nonautos entering the array (e.g., at Trap 1) in Lane 2 was about the same in the Before and After phases. Thus, it appears that more of these vehicles exited in the After study. It is unfortunate that all lanes could not be instrumented because the above suggests that nonautos were perhaps better oriented to the interchange (including the impending lane drop at the second gore) in the After phase.

The mean absolute speeds of all vehicles and those coded as local or nonlocal during the day that manual coding was done in the Before phase and in the After phase are shown on the following page. The number of local and nonlocal vehicles does not sum to the total vehicles shown because manual coding was interrupted by 15 minute breaks during the day.

```
                                   INTERCHANGE 16 SOUTH
                                   GORE SIGN (BEFORE)
                                   10/13/71
                                   0930-1430


                        TRAP 1              TRAP 2              TRAP 3              TRAP 4              TRAP 5              TRAP 6
                               NON-                NON-                NON-                NON-                NON-                NON-
ABSOLUTE SPEED     TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL

 LANE 1
   N                   0     0     0      0     0     0      0     0     0      0     0     0   1969  1090    81   1984  1092    82
   MEAN             0.00  0.00  0.00   0.00  0.00  0.00   0.00  0.00  0.00   0.00  0.00  0.00  51.27 51.13 51.83  48.42 48.32 49.20
   STAND DEV        0.00  0.00  0.00   0.00  0.00  0.00   0.00  0.00  0.00   0.00  0.00  0.00   6.13  6.32  5.70   5.81  6.05  5.00
   SKEWNESS         0.00  0.00  0.00   0.00  0.00  0.00   0.00  0.00  0.00   0.00  0.00  0.00   -.02  -.15   .18   -.00  -.12   .25
   KURTOSIS         0.00  0.00  0.00   0.00  0.00  0.00   0.00  0.00  0.00   0.00  0.00  0.00   3.95  4.33  3.20   3.80  3.91  2.99

 LANE 2
   N                3045  1623   186   3044  1629   179   3084  1653   174   3058  1661   166   1139   602    74   1213   648    72
   MEAN            57.32 57.20 57.81  56.44 56.37 56.98  55.31 55.21 56.06  54.01 53.84 54.81  57.20 57.28 56.66  58.56 58.59 57.86
   STAND DEV        6.11  6.19  5.56   6.29  6.36  6.36   6.09  6.20  5.96   6.57  6.78  6.35   6.44  6.60  5.59   6.29  6.41  5.22
   SKEWNESS         -.34  -.29  -.01   -.62  -.48 -1.20    .02   .10  -.11   -.02  -.12  -.04    .17   .22   .10   -.28  -.42  -.05
   KURTOSIS         5.39  5.18  2.49   7.02  6.30  9.68   3.49  3.46  3.14   4.19  4.66  3.40   3.70  3.58  2.95   5.64  6.34  2.59

 LANE 3
   N                2531  1299   191   2532  1293   198   2492  1269   203   2518  1261   211   2468  1230   222   2379  1182   223
   MEAN            60.35 60.15 59.58  59.81 59.57 59.00  59.95 59.66 59.16  59.79 59.57 59.26  60.66 60.43 60.37  60.61 60.43 60.46
   STAND DEV        6.03  6.11  5.89   5.78  5.78  5.48   5.74  5.86  5.43   5.74  5.77  5.52   5.66  5.71  5.46   5.70  5.91  5.31
   SKEWNESS         -.20  -.17 -1.03   -.13  -.12  -.65   -.17  -.36  -.67   -.21  -.32  -.46   -.18  -.21  -.63    .36   .80  -.66
   KURTOSIS         5.11  5.10  6.69   4.55  4.12  4.53   4.76  5.03  4.55   4.27  4.19  3.65   4.61  4.59  3.81  10.08 14.32  3.80
                                   INTERCHANGE 16 SOUTH
                                   GORE SIGN (AFTER)
                                   10/4/72
                                   0930-1430


                        TRAP 1              TRAP 2              TRAP 3              TRAP 4              TRAP 5              TRAP 6
                               NON-                NON-                NON-                NON-                NON-                NON-
ABSOLUTE SPEED     TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL

 LANE 1
   N                   0     0     0      0     0     0      0     0     0      0     0     0   2120  1265    49   2153  1283    52
   MEAN             0.00  0.00  0.00   0.00  0.00  0.00   0.00  0.00  0.00   0.00  0.00  0.00  52.56 52.44 53.81  49.48 49.43 50.18
   STAND DEV        0.00  0.00  0.00   0.00  0.00  0.00   0.00  0.00  0.00   0.00  0.00  0.00   6.12  6.16  5.41   5.84  5.84  5.07
   SKEWNESS         0.00  0.00  0.00   0.00  0.00  0.00   0.00  0.00  0.00   0.00  0.00  0.00    .16   .14   .42    .08   .13   .29
   KURTOSIS         0.00  0.00  0.00   0.00  0.00  0.00   0.00  0.00  0.00   0.00  0.00  0.00   3.25  3.35  2.33   3.64  3.51  3.59

 LANE 2
   N                3048  1813    80   3198  1888    95   3220  1899   103   3220  1899    99   1147   658    54   1190   669    58
   MEAN            57.53 57.38 56.14  57.44 57.28 57.66  56.72 56.48 57.51  54.15 53.93 55.26  57.87 57.91 57.42  58.86 58.77 59.05
   STAND DEV        8.21  8.21 10.66   6.24  6.19  7.12   6.39  6.43  7.39   6.68  6.68  7.43   6.73  6.69  8.25   6.39  6.43  7.88
   SKEWNESS        -1.26 -1.48 -2.15    .03  -.02   .14    .05   .03   .28    .15   .18   .10   -.15  -.19  -.02   -.21  -.25  -.27
   KURTOSIS        10.27 10.35 10.08   3.33  3.35  2.51   3.46  3.61  2.64   3.22  3.33  2.71   4.10  4.96  2.62   4.22  4.85  2.78

 LANE 3
   N                2951  1490   348   2801  1415   333   2779  1404   325   2779  1404   329   2732  1380   325   2656  1351   318
   MEAN            60.57 60.68 60.44  60.65 60.70 60.68  60.23 60.26 60.23  59.33 59.24 59.34  60.09 59.92 60.22  60.26 60.03 60.55
   STAND DEV        6.10  6.22  5.50   5.91  6.05  5.41   5.79  5.93  5.30   5.80  5.97  5.39   5.78  5.91  5.23   5.76  5.94  5.07
   SKEWNESS          .20   .41   .01    .18   .35   .05    .12   .29  -.11    .08   .22  -.14    .07   .25  -.12    .01   .10  -.01
   KURTOSIS         3.93  4.00  3.13   3.85  3.82  3.10   3.77  3.68  3.20   3.74  3.75  3.04   3.86  3.48  3.04   4.66  5.36  2.91
```

Mean speeds are about the same in the two phases and the speeds of local and nonlocal vehicles are also about the same. Speed is generally reduced at Trap 4 in Lane 2 which is probably attributable to the fact that about two-thirds of the vehicles striking this trap will exit at Trap 5 (refer to the sample size, N, at Traps 4 and 5 in Lanes 1 and 2).

Tables showing the proportion of vehicles meeting the various criteria defined in Chapter V are presented next. Lane placement of the exiting and through vehicle populations is presented last.

Data within each table (or each set of Before and After tables for the lane placement data) are paired by weekday. In other words, the first table shows data collected on October 13, 1971 and October 4, 1972, both Thursdays. Scheduled Before phase data collection was delayed a week by weather which accounts for the fact that data collected at this site are separated by a year and week rather than just one year as originally planned.

Each table is accompanied by annotations and, for lane placement data, illustrations which highlight features of the table.

	INTERCHANGE 16 SOUTH GCRE SIGN (BEFORE) 10/13/71 0930-1430	INTERCHANGE 16 SOUTH GORE SIGN (AFTER) 10/4/72 0930-1430							
	AUTOS	AUTCS		NONAUTOS	NCNAUTOS		ALL	ALL	
	4964	5262		612	737		5576	5999	
1. SPEED DIFFERENCE	.22683 .01165	.20582 .01092	↓	.33824 .03748	.30801 .03333	N.S.	.23906 .01119	.21837 .01045	↓
2. HEACWAY VICLATION	.10234 .00843	.11973 .00877	↑	.06536 .01958	.08412 .02004	N.S.	.09828 .00781	.11535 .00808	↑
3. HAZARDOUS MANUEVERS	.01027 .00281	.01672 .00346	↑	.00327 .00452	.00407 .00460	N.S.	.00951 .00255	.01517 .00309	↑
4. 1 + 2	.07998 .00755	.08742 .00763	N.S.	.07190 .02047	.07056 .01849	N.S.	.07909 .00708	.08535 .00707	N.S.
5. 2 + 3	.00403 .00176	.00437 .00178	N.S.	.00163 .00320	0.00000 0.00000		.00377 .00161	.00383 .00156	N.S.
6. 1 + 3	.01048 .00283	.00722 .00229	N.S.	.00490 .00553	.00136 .00266	N.S.	.00986 .00259	.00650 .00203	↓
7. 1 + 2 + 3	.00685 .00229	.00570 .00203	N.S.	.00327 .00452	.00407 .00460	N.S.	.00646 .00210	.00550 .00187	N.S.
8. NORMAL	.55923 .01381	.55302 .01343	N.S.	.51144 .03960	.52782 .03604	N.S.	.55398 .01305	.54992 .01259	N.S.
9. DBL LANE CHANGES	.02558 .00439	.02547 .00426	N.S.	.00817 .00713	.00543 .00530	N.S.	.02367 .00399	.02300 .00379	N.S.

The proportion of vehicles traveling at least 5 mph less than the mean speed for all vehicles is significantly reduced in the After phase for autos and for the population as a whole. For the same groups, however, headway violations and hazardous maneuvers are increased. Although the differences reach the .05 level of significance or better, the magnitude of the changes is small. The proportion of vehicles performing double lane changes and falling into the normal category is not significantly different in the two study periods.

INTERCHANGE 16 SOUTH
GORE SIGN (BEFORE)
10/14/71
0930-1430

INTERCHANGE 16 SOUTH
GORE SIGN (AFTER)
10/5/72
0930-1430

		AUTOS 5359	AUTOS 5336		NONAUTOS 629	NONAUTOS 737		ALL 5988	ALL 6073	
1.	SPEED DIFFERENCE	.26068 .01175	.20783 .01089	↓	.38474 .03802	.32293 .03376	↓	.27371 .01129	.22180 .01045	↓
2.	HEADWAY VIOLATION	.10767 .00830	.10757 .00831	N.S.	.06518 .01929	.07870 .01944	N.S.	.10321 .00771	.10407 .00768	N.S.
3.	HAZARDOUS MANEUVERS	.01157 .00286	.01406 .00316	N.S.	.00954 .00760	.00407 .00460	N.S.	.01136 .00268	.01284 .00283	N.S.
4.	1 + 2	.09125 .00771	.09033 .00769	N.S.	.06677 .01951	.08548 .02019	N.S.	.08868 .00720	.08974 .00719	N.S.
5.	2 + 3	.00205 .00121	.00562 .00201	↑	.00159 .00311	.00814 .00649	N.S.	.00200 .00113	.00593 .00193	↑
6.	1 + 3	.01213 .00293	.00825 .00243	↓	.00159 .00311	.01764 .00950	↑	.01102 .00264	.00939 .00243	N.S.
7.	1 + 2 + 3	.00933 .00257	.00637 .00213	N.S.	.00636 .00621	.00678 .00593	N.S.	.00902 .00239	.00642 .00201	N.S.
8.	NORMAL	.50532 .01339	.55997 .01332	↑	.46423 .03898	.47626 .03606	N.S.	.50100 .01266	.54981 .01251	↑
9.	DBL LANE CHANGES	.02351 .00406	.02549 .00423	N.S.	.00954 .00760	.01764 .00950	N.S.	.02204 .00372	.02453 .00389	N.S.

For this set of paired data collection days, speed differences are also significantly reduced. The increase in headway violations and hazardous maneuvers alone is not found for this pair of days. However, the proportion of vehicles meeting both these criteria (Item 5) is increased. There is no significant difference in double lane changes, as was also found in the other pair of days.

INTERCHANGE 16 SOUTH
GORE SIGN (BEFORE)
10/13/71
0930-1430

INTERCHANGE 16 SOUTH
GORE SIGN (AFTER)
10/4/72
0930-1430

	LOCAL	LOCAL	FOREIGN	FOREIGN	ALL	ALL
	2922	3303	377	428	3299	3731
1. SPEED DIFFERENCE	.24538 .01560	.22010 .01413 ↓	.25199 .04383	.22196 .03937 N.S.	.24614 .01470	.22032 .01330 ↓
2. HEADWAY VIOLATION	.10404 .01107	.12352 .01122 ↑	.05305 .02263	.10748 .02934 ↑	.09821 .01016	.12168 .01049 ↑
3. HAZARDOUS MANUEVERS	.01164 .00389	.01423 .00404 N.S.	.00796 .00897	.01168 .01018 N.S.	.01122 .00359	.01394 .00376 N.S.
4. 1 + 2	.08590 .01016	.09779 .01013 N.S.	.04244 .02035	.04673 .02000 N.S.	.08093 .00931	.09193 .00927 N.S.
5. 2 + 3	.00342 .00212	.00303 .00187 N.S.	.00531 .00733	.00234 .00457 N.S.	.00364 .00205	.00295 .00174 N.S.
6. 1 + 3	.00753 .00313	.00636 .00271 N.S.	.01061 .01034	.00935 .00912 N.S.	.00788 .00302	.00670 .00262 N.S.
7. 1 + 2 + 3	.00856 .00334	.00484 .00237 N.S.	0.00000 0.00000	.00234 .00457	.00758 .00296	.00456 .00216 N.S.
8. NORMAL	.53354 .01809	.53012 .01702 N.S.	.62865 .04877	.59813 .04645 N.S.	.54441 .01699	.53793 .01600 N.S.
9. DBL LANE CHANGES	.02567 .00573	.01968 .00474 N.S.	.02387 .01541	.02103 .01359 N.S.	.02546 .00538	.01983 .00447 N.S.

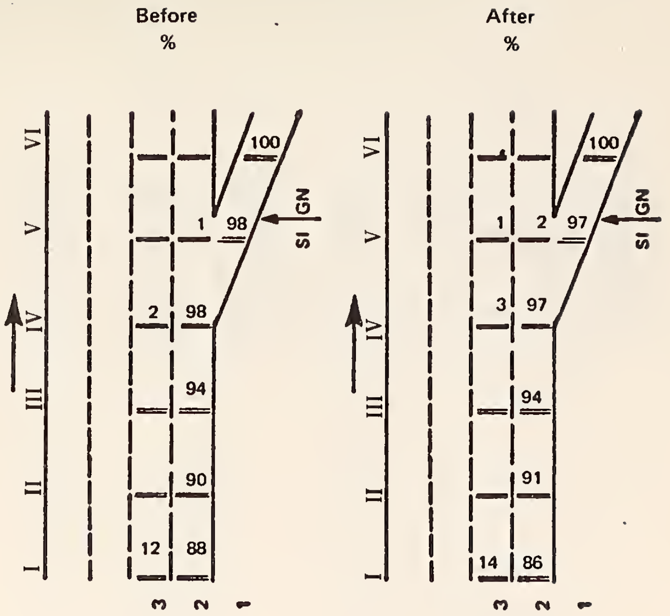
With the exception of hazardous maneuvers which are not significantly different for either the local or foreign subpopulations in the After phase, these data parallel that for autos and for the population as a whole measured on the same day.

From these three tables, the small but significant reduction in the proportion of vehicles traveling at lower speeds is offset by the suggestion that headway violations and hazardous maneuvers have increased. It is concluded that these three tables show no benefit to have accrued at this interchange following the installation of diagrammatic signs.

INTERCHANGE 16 SOUTH
GORE SIGN (AFTER)
10/4/72
0930-1430

EXIT TRAFFIC
2153

	TRAP 1	2	3	4	5	6
1 N	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.7227 .0189	.7473 .0184
1 HV	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.0497 .0092	.0525 .0094
1 LS	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.1607 .0155	.1612 .0155
1 HV+LS	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.0409 .0084	.0390 .0082
2 N	.6033 .0207	.6298 .0204	.6345 .0203	.6368 .0203	.0098 .0042	0.0000 0.0000
2 HV	.0999 .0127	.0952 .0124	.0906 .0121	.0762 .0112	0.0000 0.0000	0.0000 0.0000
2 LS	.1259 .0140	.1449 .0149	.1570 .0154	.2002 .0169	.0102 .0042	0.0000 0.0000
2 HV+LS	.0307 .0073	.0404 .0083	.0557 .0097	.0595 .0100	.0005 .0009	0.0000 0.0000
3 N	.1050 .0129	.0687 .0107	.0488 .0091	.0176 .0056	.0037 .0026	0.0000 0.0000
3 HV	.0158 .0053	.0084 .0038	.0060 .0033	.0028 .0022	.0014 .0016	0.0000 0.0000
3 LS	.0153 .0052	.0084 .0038	.0065 .0034	.0060 .0033	.0005 .0009	0.0000 0.0000
3 HV+LS	.0042 .0027	.0042 .0027	.0009 .0013	.0009 .0013	0.0000 0.0000	0.0000 0.0000



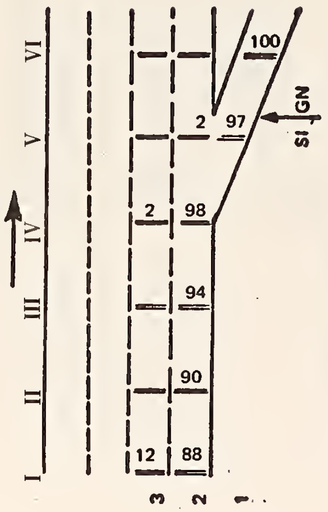
TOTALS LANE 1	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.9740 .0067	1.0000 0.0000
TOTALS LANE 2	.8597 .0147	.9104 .0121	.9378 .0102	.9726 .0069	.0204 .0060	0.0000 0.0000
TOTALS LANE 3	.1403 .0147	.0896 .0121	.0622 .0102	.0274 .0069	.0056 .0031	0.0000 0.0000

Lane usage for the Wednesday paired data for exiting traffic is summarized in the table at the right and the illustration above it (the Before phase data are presented on the following page). When the proportions in the table at the right are compared to those on the following page, it will be found that none of the differences reach the .05 level of significance. (See Chapter V for the procedure for determining significance levels from the proportions and confidence intervals provided in the tables.)

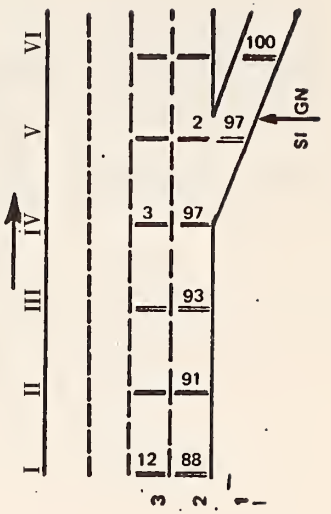
```
                    INTERCHANGE 16 SOUTH
                    GORE SIGN (BEFORE)
                    10/13/71
                    0930-1430

EXIT TRAFFIC                        TRAP
   1984                1       2       3       4       5       6

            1 N     0.0000  0.0000  0.0000  0.0000   .7162   .7621
                    0.0000  0.0000  0.0000  0.0000   .0198   .0187

            1 HV    0.0000  0.0000  0.0000  0.0000   .0439   .0418
                    0.0000  0.0000  0.0000  0.0000   .0090   .0088

            1 LS    0.0000  0.0000  0.0000  0.0000   .1890   .1658
                    0.0000  0.0000  0.0000  0.0000   .0172   .0164

            1 HV+LS 0.0000  0.0000  0.0000  0.0000   .0323   .0302
                    0.0000  0.0000  0.0000  0.0000   .0078   .0075

            2 N      .6064   .6205   .6280   .6230   .0066  0.0000
                     .0215   .0214   .0213   .0213   .0036  0.0000

            2 HV     .0766   .0726   .0721   .0580   .0005  0.0000
                     .0117   .0114   .0114   .0103   .0010  0.0000

            2 LS     .1578   .1678   .1895   .2364   .0071  0.0000
                     .0160   .0164   .0172   .0187   .0037  0.0000

            2 HV+LS  .0388   .0358   .0529   .0590   .0005  0.0000
                     .0085   .0082   .0099   .0104   .0010  0.0000

            3 N      .0297   .0761   .0383   .0096   .0025  0.0000     TOTALS   0.0000  0.0000  0.0000  0.0000   .9814  1.0000
                     .0126   .0117   .0084   .0043   .0022  0.0000     LANE 1   0.0000  0.0000  0.0000  0.0000   .0060  0.0000

            3 HV     .0091   .0066   .0035   .0015   .0005  0.0000     TOTALS    .8795   .8967   .9425   .9763   .0146  0.0000
                     .0042   .0036   .0026   .0017   .0010  0.0000     LANE 2    .0143   .0134   .0102   .0067   .0053  0.0000

            3 LS     .0146   .0171   .0126   .0116   .0010  0.0000     TOTALS    .1205   .1033   .0575   .0237   .0040  0.0000
                     .0053   .0057   .0049   .0047   .0014  0.0000     LANE 3    .0143   .0134   .0102   .0067   .0028  0.0000

            3 HV+LS  .0071   .0035   .0030   .0010  0.0000  0.0000
                     .0037   .0026   .0024   .0014  0.0000  0.0000
```

```
                      INTERCHANGE 16 SOUTH
                      GORE SIGN (AFTER)
                      10/5/72
                      0930-1430

EXIT TRAFFIC                              TRAP
   2167                1        2        3        4         5        6

          1 N       0.0000   0.0000   0.0000   0.0000    .7111    .7448
                    0.0000   0.0000   0.0000   0.0000    .0191    .0184

          1 HV      0.0000   0.0000   0.0000   0.0000    .0558    .0581
                    0.0000   0.0000   0.0000   0.0000    .0097    .0099

          1 LS      0.0000   0.0000   0.0000   0.0000    .1675    .1564
                    0.0000   0.0000   0.0000   0.0000    .0157    .0153

          1 HV+LS   0.0000   0.0000   0.0000   0.0000    .0374    .0406
                    0.0000   0.0000   0.0000   0.0000    .0080    .0083

          2 N        .6073    .6101    .6193    .6193    .0060   0.0000
                     .0206    .0205    .0204    .0204    .0033   0.0000

          2 HV       .0918    .0969    .0891    .0803    .0005   0.0000
                     .0122    .0125    .0120    .0114    .0009   0.0000

          2 LS       .1375    .1532    .1638    .2072    .0148   0.0000
                     .0145    .0152    .0156    .0171    .0051   0.0000

          2 HV+LS    .0461    .0489    .0609    .0641    .0009   0.0000
                     .0088    .0091    .0101    .0103    .0013   0.0000

          3 N        .0923    .0692    .0485    .0180    .0037   0.0000
                     .0122    .0107    .0090    .0056    .0026   0.0000

          3 HV       .0115    .0102    .0074    .0042    .0014   0.0000
                     .0045    .0042    .0036    .0027    .0016   0.0000

          3 LS       .0111    .0097    .0097    .0065    .0005   0.0000
                     .0044    .0041    .0041    .0034    .0009   0.0000

          3 HV+LS    .0023    .0018    .0014    .0005    .0005   0.0000
                     .0020    .0018    .0016    .0009    .0009   0.0000
```

Before
%



After
%



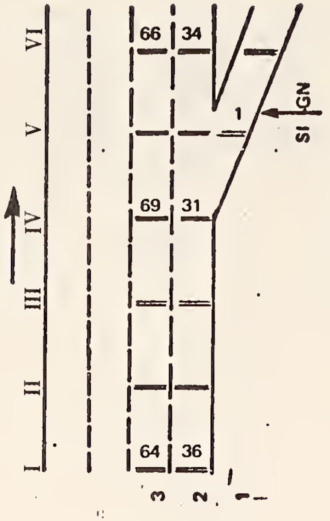
```
TOTALS    0.0000   0.0000   0.0000   0.0000    .9719   1.0000
LANE 1    0.0000   0.0000   0.0000   0.0000    .0070   0.0000

TOTALS     .6828    .9091    .9331    .9709    .0222   0.0000
LANE 2     .0135    .0121    .0105    .0071    .0062   0.0000

TOTALS     .1172    .0909    .0669    .0291    .0060   0.0000
LANE 3     .0135    .0121    .0105    .0071    .0033   0.0000
```

Lane usage for the Thursday paired data parallels that collected on Wednesday. When the proportions in the table at right above are compared to those in the same table for the Before phase on the following page, none of the differences reach the .05 level of significance.

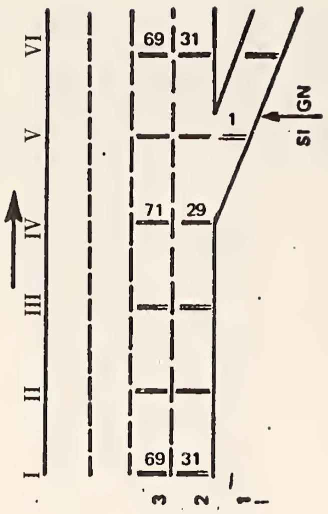
```
                    INTERCHANGE 16 SOUTH
                    GORE SIGN (BEFORE)
                    10/14/71
                    0930-1430

EXIT TRAFFIC                          TRAP
   2010                  1       2       3       4       5       6

          1 N         0.0000  0.0000  0.0000  0.0000   .6065   .5483
                      0.0000  0.0000  0.0000  0.0000   .0214   .0218

          1 HV        0.0000  0.0000  0.0000  0.0000   .0428   .0343
                      0.0000  0.0000  0.0000  0.0000   .0088   .0080

          1 LS        0.0000  0.0000  0.0000  0.0000   .2791   .3716
                      0.0000  0.0000  0.0000  0.0000   .0196   .0211

          1 HV+LS     0.0000  0.0000  0.0000  0.0000   .0408   .0458
                      0.0000  0.0000  0.0000  0.0000   .0086   .0091

          2 N          .6199   .6269   .6229   .5900   .0090  0.0000
                       .0212   .0211   .0212   .0215   .0041  0.0000

          2 HV         .0871   .0891   .0856   .0751   .0005  0.0000
                       .0123   .0125   .0122   .0115   .0010  0.0000

          2 LS         .1363   .1408   .1801   .2512   .0114  0.0000
                       .0150   .0152   .0168   .0190   .0046  0.0000

          2 HV+LS      .0388   .0403   .0493   .0587   .0035  0.0000
                       .0084   .0086   .0095   .0103   .0026  0.0000

          3 N          .0841   .0776   .0443   .0169   .0040  0.0000      TOTALS    0.0000  0.0000  0.0000  0.0000   .9692  1.0000
                       .0121   .0117   .0090   .0056   .0028  0.0000      LANE 1    0.0000  0.0000  0.0000  0.0000   .0076  0.0000

          3 HV         .0164   .0090   .0045   .0005   .0005  0.0000      TOTALS     .8821   .8970   .9378   .9751   .0244  0.0000
                       .0056   .0041   .0029   .0010   .0010  0.0000      LANE 2     .0141   .0133   .0106   .0068   .0367  0.0000

          3 LS         .0134   .0124   .0109   .0070   .0015  0.0000      TOTALS     .1179   .1030   .0622   .0249   .0065  0.0000
                       .0050   .0048   .0045   .0036   .0017  0.0000      LANE 3     .0141   .0133   .0106   .0068   .0035  0.0000

          3 HV+LS      .0040   .0040   .0025   .0005   .0005  0.0000
                       .0028   .0028   .0022   .0010   .0010  0.0000
```

```
                        INTERCHANGE 16 SOUTH
                        GORE SIGN (AFTER)
                        10/4/72
                        0930-1430

THRU TRAFFIC                              TRAP
   3846                  1        2        3        4         5        6

          1 N         0.0000   0.0000   0.0000   0.0000     .0039   0.0000
                      0.0000   0.0000   0.0000   0.0000     .0020   0.0000

          1 HV        0.0000   0.0000   0.0000   0.0000     .0003   0.0000
                      0.0000   0.0000   0.0000   0.0000     .0005   0.0000

          1 LS        0.0000   0.0000   0.0000   0.0000     .0016   0.0000
                      0.0000   0.0000   0.0000   0.0000     .0012   0.0000

          1 HV+LS     0.0000   0.0000   0.0000   0.0000     .0003   0.0000
                      0.0000   0.0000   0.0000   0.0000     .0005   0.0000

          2 N          .2293    .2439    .2452    .2317     .2283    .2460
                       .0133    .0136    .0136    .0133     .0133    .0136

          2 HV         .0239    .0205    .0161    .0221     .0091    .0122
                       .0048    .0045    .0040    .0046     .0030    .0035

          2 LS         .0463    .0463    .0382    .0276     .0452    .0460
                       .0066    .0066    .0061    .0052     .0066    .0066

          2 HV+LS      .0117    .0112    .0127    .0114     .0042    .0052
                       .0034    .0033    .0035    .0034     .0020    .0023

          3 N          .5068    .5104    .5260    .5411     .5289    .5190
                       .0158    .0158    .0158    .0157     .0158    .0158

          3 HV         .0507    .0484    .0468    .0486     .0502    .0562
                       .0069    .0068    .0067    .0068     .0069    .0073

          3 LS         .1154    .1048    .1024    .1037     .1121    .1024
                       .0101    .0097    .0096    .0096     .0100    .0096

          3 HV+LS      .0159    .0146    .0125    .0138     .0161    .0130
                       .0039    .0038    .0035    .0037     .0040    .0036
```

Before
%



After
%

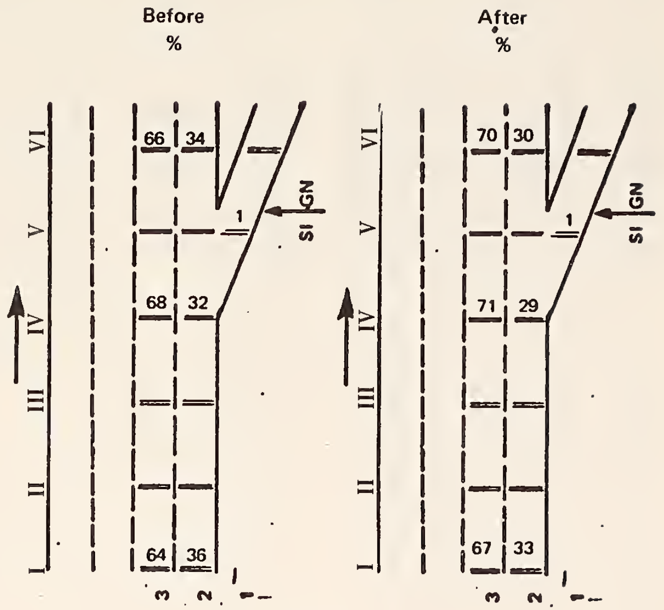


```
TOTALS     0.0000   0.0000   0.0000   0.0000    .0060   0.0000
LANE 1     0.0000   0.0000   0.0000   0.0000    .0024   0.0000

TOTALS      .3112    .3219    .3123    .2928    .2868    .3094
LANE 2      .0146    .0148    .0146    .0144    .0143    .0146

TOTALS      .6888    .6781    .6877    .7072    .7072    .6906
LANE 3      .0146    .0148    .0146    .0144    .0144    .0146
```

For the through traffic subpopulation, there is no significant difference in the incidence of exit returns (through vehicles which begin to exit, i.e., strike Trap 5 in the exit ramp). The proportion of through vehicles in Lane 2 throughout the array is generally reduced (most of the proportions are significantly different at the .05 level) which suggests an improvement in through traffic behavior. However, at this interchange, the situation is complicated by the presence of a second gore just downstream. Data at the second gore must be reviewed before this shift can be accepted as favorable.

```
                     INTERCHANGE 16 SOUTH
                     GORE SIGN (BEFORE)
                     10/13/71
                     0930-1430

THRU TRAFFIC                             TRAP
   3592                 1        2        3        4        5        6

        1 N          0.0000   0.0000   0.0000   0.0000    .0028   0.0000
                     0.0000   0.0000   0.0000   0.0000    .0017   0.0000

        1 HV         0.0000   0.0000   0.0000   0.0000    .0006   0.0000
                     0.0000   0.0000   0.0000   0.0000    .0008   0.0000

        1 LS         0.0000   0.0000   0.0000   0.0000    .0019   0.0000
                     0.0000   0.0000   0.0000   0.0000    .0014   0.0000

        1 HV+LS      0.0000   0.0000   0.0000   0.0000    .0008   0.0000
                     0.0000   0.0000   0.0000   0.0000    .0009   0.0000

        2 N           .2756    .2714    .2639    .2455    .2300    .2483
                      .0146    .0145    .0144    .0141    .0138    .0141

        2 HV          .0206    .0206    .0192    .0192    .0097    .0125
                      .0046    .0046    .0045    .0045    .0032    .0036

        2 LS          .0568    .0501    .0426    .0359    .0651    .0721
                      .0076    .0071    .0066    .0061    .0081    .0085

        2 HV+LS       .0089    .0100    .0122    .0114    .0042    .0047
                      .0031    .0033    .0036    .0035    .0021    .0022

        3 N           .4880    .4994    .5064    .5248    .5281    .4969      TOTALS    0.0000   0.0000   0.0000   0.0000    .0061   0.0000
                      .0163    .0164    .0164    .0163    .0163    .0164      LANE 1    0.0000   0.0000   0.0000   0.0000    .0026   0.0000

        3 HV          .0348    .0359    .0365    .0362    .0381    .0479      TOTALS     .3619    .3522    .3380    .3121    .3090    .3377
                      .0060    .0061    .0061    .0061    .0063    .0070      LANE 2     .0157    .0156    .0155    .0152    .0151    .0155

        3 LS          .1047    .1047    .1089    .1155    .1075    .1058      TOTALS     .6381    .6478    .6620    .6879    .6849    .6623
                      .0100    .0100    .0102    .0105    .0101    .0101      LANE 3     .0157    .0156    .0155    .0152    .0152    .0155

        3 HV+LS       .0106    .0078    .0103    .0114    .0111    .0117
                      .0033    .0029    .0033    .0035    .0034    .0035
```

```
                         INTERCHANGE 16 SOUTH
                         GORE SIGN (AFTER)
                         10/5/72
                         0930-1430

THRU TRAFFIC                                TRAP
   3906                 1        2        3        4        5        6

           1 N       0.0000   0.0000   0.0000   0.0000    .0038   0.0000
                     0.0000   0.0000   0.0000   0.0000    .0019   0.0000

           1 HV      0.0000   0.0000   0.0000   0.0000    .0003   0.0000
                     0.0000   0.0000   0.0000   0.0000    .0005   0.0000

           1 LS      0.0000   0.0000   0.0000   0.0000    .0015   0.0000
                     0.0000   0.0000   0.0000   0.0000    .0012   0.0000

           1 HV+LS   0.0000   0.0000   0.0000   0.0000    .0005   0.0000
                     0.0000   0.0000   0.0000   0.0000    .0007   0.0000

           2 N        .2404    .2455    .2435    .2299    .2181    .2256
                      .0134    .0135    .0135    .0132    .0130    .0131

           2 HV       .0236    .0202    .0200    .0218    .0059    .0084
                      .0048    .0044    .0044    .0046    .0024    .0029

           2 LS       .0558    .0499    .0407    .0325    .0586    .0645
                      .0072    .0068    .0062    .0056    .0074    .0077

           2 HV+LS    .0092    .0100    .0092    .0092    .0044    .0044
                      .0028    .0031    .0030    .0030    .0021    .0021

           3 N        .5092    .5151    .5279    .5438    .5430    .5292
                      .0157    .0157    .0157    .0156    .0156    .0157

           3 HV       .0392    .0366    .0353    .0387    .0438    .0456
                      .0061    .0059    .0058    .0060    .0064    .0065

           3 LS       .1121    .1116    .1101    .1075    .1055    .1065
                      .0099    .0099    .0098    .0097    .0096    .0097

           3 HV+LS    .0115    .0110    .0133    .0166    .0146    .0159
                      .0033    .0033    .0036    .0040    .0038    .0039
```



```
TOTALS     0.0000   0.0000   0.0000   0.0000    .0061   0.0000
LANE 1     0.0000   0.0000   0.0000   0.0000    .0025   0.0000

TOTALS      .3280    .3257    .3134    .2934    .2870    .3029
LANE 2      .0147    .0147    .0145    .0143    .0142    .0144

TOTALS      .6720    .6743    .6866    .7066    .7069    .6971
LANE 3      .0147    .0147    .0145    .0143    .0143    .0144
```

The data for through traffic lane placement on Thursday parallel the results obtained on Wednesday. There is no significant difference in exit returns in the two study periods. A significantly smaller proportion of the through vehicles studied were found in Lane 2 and a significantly larger proportion in Lane 3.

```
                    INTERCHANGE 15 SOUTH
                    GORE SIGN (BEFORE)
                    10/14/71
                    0930-1430

THRU TRAFFIC                        TRAP
   3978                1       2       3       4        5       6

         1 N        0.0000  0.0000  0.0000  0.0000    .0033  0.0000
                    0.0000  0.0000  0.0000  0.0000    .0018  0.0000

         1 HV       0.0000  0.0000  0.0000  0.0000    .0003  0.0000
                    0.0000  0.0000  0.0000  0.0000    .0005  0.0000

         1 LS       0.0000  0.0000  0.0000  0.0000    .0033  0.0000
                    0.0000  0.0000  0.0000  0.0000    .0018  0.0000

         1 HV+LS    0.0000  0.0000  0.0000  0.0000    .0005  0.0000
                    0.0000  0.0000  0.0000  0.0000    .0007  0.0000

         2 N         .2707   .2700   .2642   .2459    .2328   .2421
                     .0138   .0138   .0137   .0134    .0131   .0133

         2 HV        .0249   .0249   .0241   .0226    .0088   .0131
                     .0048   .0048   .0048   .0046    .0029   .0035

         2 LS        .0588   .0500   .0445   .0395    .0639   .0749
                     .0073   .0068   .0064   .0061    .0076   .0082

         2 HV+LS     .0103   .0096   .0098   .0113    .0038   .0055
                     .0031   .0030   .0031   .0033    .0019   .0023

         3 N         .4809   .4982   .5075   .5289    .5196   .4849    TOTALS   0.0000  0.0000  0.0000  0.0000    .0073  0.0000
                     .0155   .0155   .0155   .0155    .0155   .0155    LANE 1   0.0000  0.0000  0.0000  0.0000    .0026  0.0000

         3 HV        .0395   .0375   .0390   .0385    .0415   .0513    TOTALS    .3648   .3544   .3426   .3193    .3092   .3356
                     .0061   .0059   .0060   .0060    .0062   .0069    LANE 2    .0150   .0149   .0147   .0145    .0144   .0147

         3 LS        .1056   .1011   .0993   .1033    .1101   .1134    TOTALS    .6352   .6456   .6574   .6807    .6835   .6644
                     .0095   .0094   .0093   .0095    .0097   .0099    LANE 3    .0150   .0149   .0147   .0145    .0145   .0147

         3 HV+LS     .0093   .0088   .0116   .0101    .0123   .0148
                     .0030   .0029   .0033   .0031    .0034   .0038
```

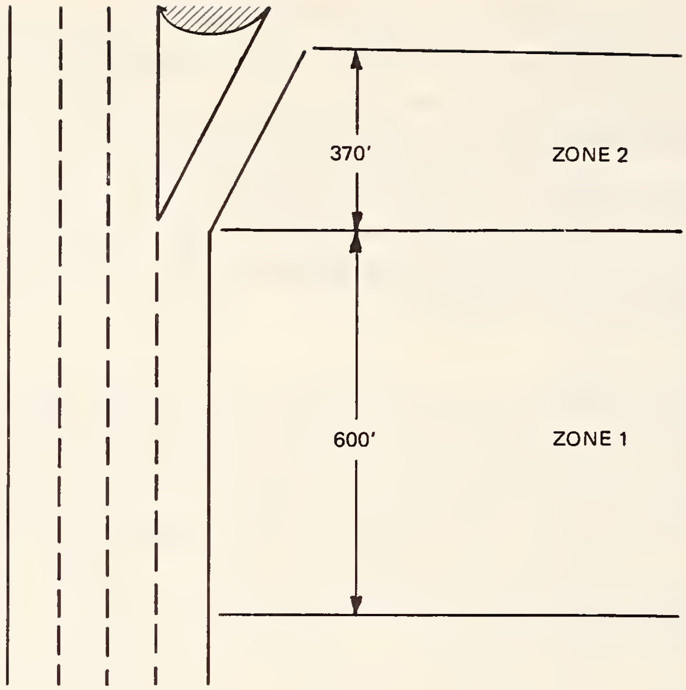
To summarize, only two of the four through traffic lanes were instrumented at the first gore. The exit ramp was also instrumented. Of the traffic measured, about 35 percent exited. Results from the proportions of vehicles meeting the various criteria for speed differences, headway violations, hazardous maneuvers and various combinations of these were mixed. A significant decrease in the proportions of vehicles traveling at least 5 mph less than the mean speed in the After phase was found but this was offset by the increase in headway violations and hazardous maneuvers. From the tables presenting these data, it was concluded that no benefit from the diagrammatics was found.

No significant difference was found in lane placement for exiting traffic in the After phase. For through traffic, exit returns were not significantly reduced but the incidence of these in both phases was very low. Of the through vehicles studied, a significantly lower proportion of them were found in the rightmost lane and a significantly higher proportion in the next lane towards the median. This is generally interpreted as a favorable effect suggesting that more of these vehicles are confident in their decision not to exit at this ramp. Before this interpretation is fully accepted, however, it must be seen whether there were any dis-beneficial effects at the second gore. From the data at this gore alone, it must be concluded that the diagrammatics did not significantly improve performance.

Attention is now turned to the data collected by means of time-lapse photography at the second gore and at the exit direction and advance signs.

Second Gore (Glen Echo). There is a lane drop at this gore. The right lane continues as the exit ramp reducing the number of through traffic lanes from four to three. Fourteen percent of the total traffic volume exits at this gore.

Vehicular maneuvers were scored in two zones. The zone at the gore proper (Zone 2) extended from the tip of the painted gore to a physical barrier and covered 370 feet. Zone 1 extended from the painted gore 600 feet upstream.



16 SOUTH–SECOND GORE

The following types of maneuvers were scored in these zones:

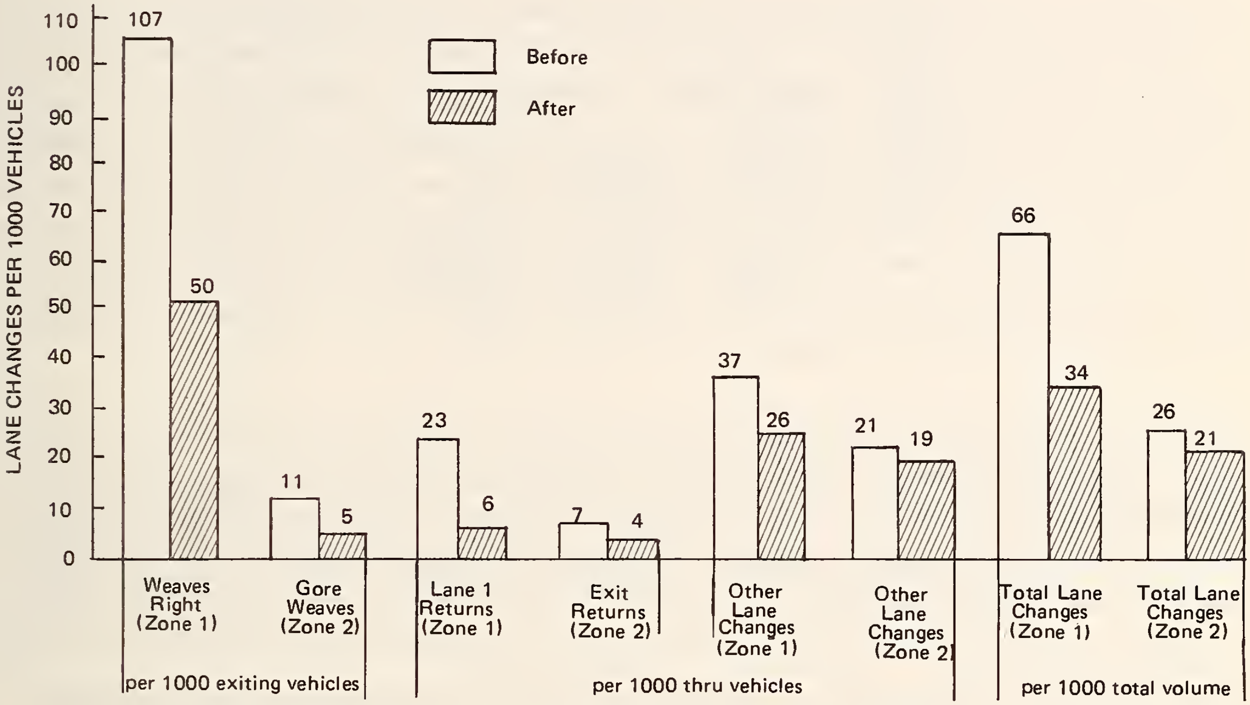
Zone 2

- gore weaves (lane changes across the painted gore)–expressed per thousand exiting vehicles.
- exit returns (lane changes from the exit ramp back to the through traffic lanes)–expressed per thousand through vehicles.
- other lane changes–expressed per thousand through vehicles.

Zone 1

- weaves right (movements to the right-most lane made by exiting vehicles)–expressed per thousand exiting vehicles.
- Lane 1 returns (movements out of the right lane)–expressed per thousand through vehicles.
- other lane changes–expressed per thousand through vehicles.

In Zone 2, decreases in the After phase were found in every category of maneuvers defined. Thus, gore weaves averaged 11 per thousand exiting vehicles under conventional signing. In the diagrammatic condition, this average dropped to five per thousand. The incidence of these maneuvers is small in both Before and After phases, however, and the differences are not significant (z=.71).



LANE CHANGES AT 16 SOUTH: SECOND GORE

Exit returns also dropped from seven per thousand through vehicles to about four. This difference is also insignificant (z=1.66). Other lane changes showed a decline from an average of 21 per thousand through vehicles to about 19, also an insignificant difference.

The total difference in this zone was therefore insignificant (z=.98). Average lane changes per thousand total volume declined from 26 Before to 21 After.

In the zone which extended from the tip of the painted gore to 600 feet upstream (Zone 1), the declines in the After phase were significant in every category. Weaves right dropped from an average of 107 per thousand exit volume to about 50 per thousand. The difference is significant at the .01 level (z=3.36).

Lane 1 returns dropped from an average of 23 per thousand through vehicles under conventional signing to six per thousand under diagrammatics. This decline is also significant at the .01 level (z=5.48). Other lane changes declined from 37 Before (also per thousand through vehicles) to about 26 After. This difference is significant at the .05 level (z=2.29). In this zone, total lane changes per thousand total volume dropped from 66 Before to 34 After, a difference significant at the .01 level (z=6.15).

In summary, the above data indicate an improvement in vehicular movement in the After phase at the second gore. It will be remembered that the TES data at the first gore showed no significant change in exiting traffic behavior at that gore but a possible benefit in through traffic behavior as measured by lane placement. The latter conclusion was made with provision that data at the second gore did not indicate that the change in through vehicular behavior at the first gore resulted in increased maneuvering at the second gore. The data presented above indicate that at the gore itself (Zone 2) there are no disbeneficial effects. Upstream (Zone 1) vehicular maneuver data indicate performance has been improved with a significant reduction in all categories of vehicle movements.

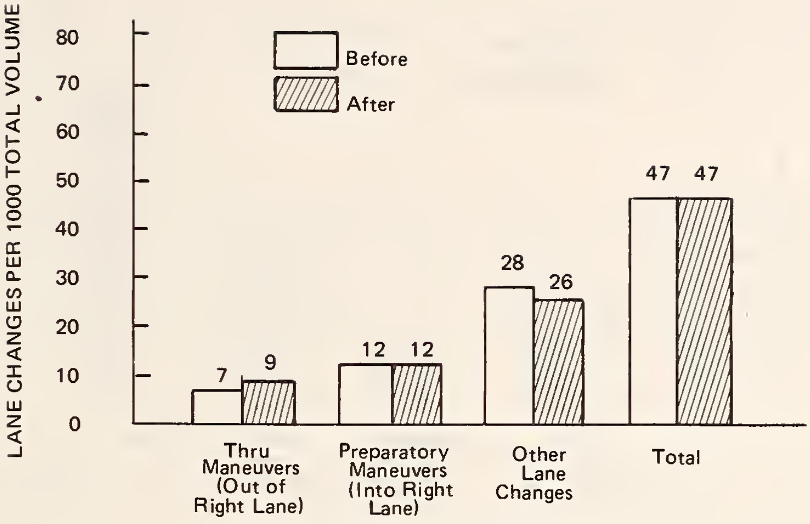
The data are consistent in showing improved through vehicle performance at the first gore (but no significant difference in exiting vchicle performance) and improved performance of both exiting and through traffic at the second gore. The improved performance at the second gore is found in Zone 1, upstream from the second gore and primarily the stretch of roadway between the first and second gores.

Exit Direction (G-1) Sign. The zone scored from the film extended from 650 feet upstream from the sign to the sign itself. Through maneuvers, preparatory maneuvers and other lane changes were counted and expressed per thousand total traffic volume.

All three categories of lane changes scored showed little difference between the Before and After phases. Through maneuvers (movements out of thc right lane) average seven per thousand total volume in 1971 and nine per thousand in 1972. This is an insignificant difference (z=1.18).

The incidence of movements into the right lane (preparatory maneuvers) was the same in 1971 and 1972; 12 per thousand total volume.

Other lane changes also showed an insignificant change (z=.72). Lane changes per thousand total volume in this category averaged 28 in 1971 as compared to 26 in 1972.



LANE CHANGES AT 16 SOUTH: G-1

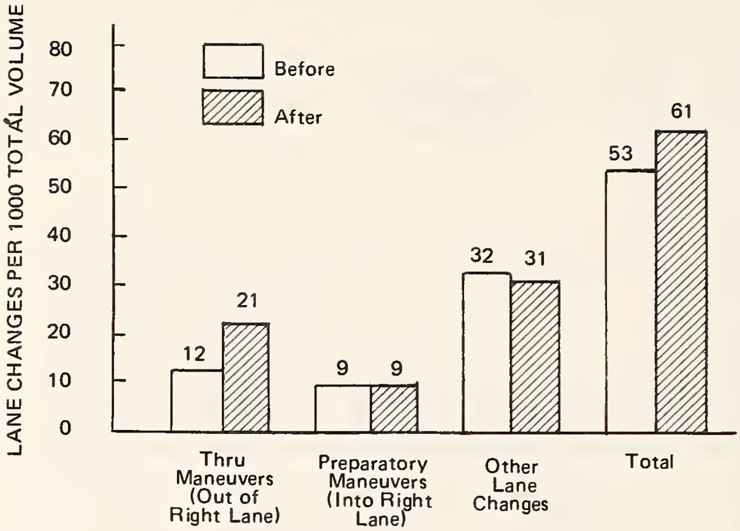
Total lane changes averaged 47 per thousand in both phases, also an insignificant difference.

Thus, the improvement in traffic behavior noted at the first and second gores is not attributed to changes in lane placement maneuvers in the vicinity of the exit direction sign.

Advance (G-2) Sign. Preparatory maneuvers, through maneuvers and other lane changes were scored for a zone extending from 350 feet upstream from the sign to the sign itself.

At this location through maneuvers were the only category significantly different in the After phase. These maneuvers increased from an average of 12 per thousand total volume in the Before phase to 21 per thousand in the After phase. This difference is significant at the .01 level (z=2.84).

Preparatory maneuvers remained the same, averaging nine per thousand total volume in both phases. Other maneuvers also remained about the same, averaging 32 per thousand Before as compared to 31 per thousand After.



LANE CHANGES AT 16 SOUTH: G-2

Total maneuvers, therefore, showed some increase (53 per thousand total volume Before, 61 per thousand After), but this increase is insignificant (z=1.60).

Summary. A small benefit in through vehicle performance is indicated by TES data collected at the first gore. Exiting vehicle performance was unchanged. Data collected by means of time-lapse photography indicate improved performance of both exiting and through traffic on the approach to the second gore. The changes in vehicle movements (and/or lane usage) found at the first and second gore are not attributable to a greater incidence of preparatory and through maneuvers in the vicinity of the exit direction sign because no significant changes at this location were found in the After study. However, an increase in through maneuvers (movements out of Lane 1) was found at the advance sign. The improved lane usage of through vehicles at the first gore may thus be attributable to lane changes made in the vicinity of the advance sign. The reader will find a similar phenomenon occurred at the next interchange to be discussed, 17 North. Changes measured at that gore were traced back to changes in traffic behavior initiated at the advance (rather than the exit direction) sign location.

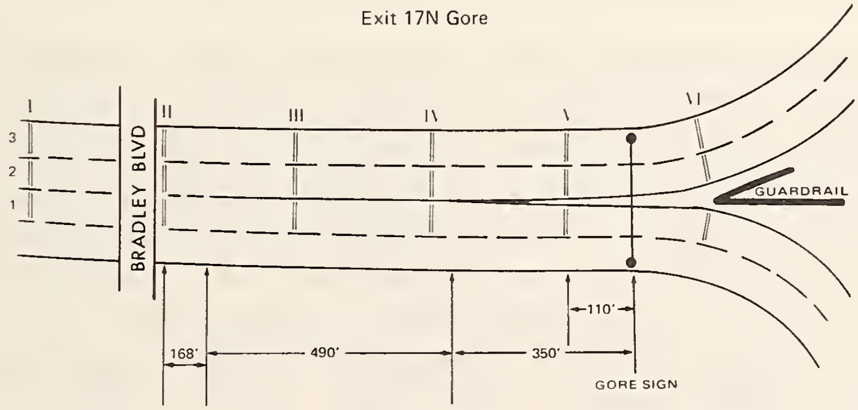
Interchange 17 North

There are three signs on the northbound approach to this major fork interchange. These are an advance (G-2), exit direction (G-1) and gore (G) sign. The Capital Beltway (I-495) is four lanes wide on the approach. At the gore, the right two lanes continue as I-495. The left two lanes continue as I-70S.

All three sign locations were instrumented with the TES. However, limitations on total input to the system allowed instrumentation of three lanes only. The right or shoulder-most lane was therefore omitted because preliminary observations suggested that the least lane changing activity at the gore involved this lane. The same lane was omitted at all three signing locations.

Because of the omission of one lane, the volume of exiting and through traffic cannot be determined from TES data. However, from film data collected in the Before phase, it was determined that 50 percent of the traffic on the approach selected the I-70S lanes and 50 percent continued on I-495. Thus, this is potentially a most interesting interchange. There is a left exit rather than the more frequently encountered right exit, and about half the traffic exits while the other half continues through. Because the left exit is unexpected to both exiting and through traffic and there are sizeable proportions of motorists moving in each direction, the possibility for reducing confusion on the part of both exiting and through motorists exists at this interchange.

Gore. Tapeswitch instrumentation at the gore was as shown below. The numbered lanes (1,2,3) correspond to numbers used in the tables which follow.



Not counting the uninstrumented lane, the percentages of traffic which continued on I-495 or followed I-70S in the Before and After data collection periods were as follows (measured at Trap 6):

		Before		After	
		8/25/71	8/26/71	8/23/72	8/24/72
I-495	Lane 1	31.6	31.8	33.8	32.8
I-70S	Lane 2	37.5	36.9	33.4	34.2
I-70S	Lane 3	30.8	31.3	32.8	33.0

The above findings suggest a more even distribution of traffic in the two exiting lanes in the After phase.

In terms of autos and nonautos, the range (across all four data collection days) in percentage hourly distribution by lanes was as follows:

	Total	Autos	Nonautos
Lane 1 (Through)	32-34	32-35	22-26
Lane 2 (Exiting)	33-38	31-36	53-62
Lane 3 (Exiting)	31-33	31-34	14-25

The measurements were made at Trap 6 at the point where the guardrail prevents further maneuvering from I-70S to I-495 lanes and vice versa. Lanes 2 and 3 are the exiting lanes which continue as I-70S. Thus, it can be seen that about 75 percent of the nonautos in the instrumented lanes exited onto I-70S, mostly via Lane 2. Autos were more evenly distributed with roughly one-third continuing in each of the three instrumented lanes.

Speeds at each trap for the days on which vehicles were manually coded (Wednesday, August 25, 1971 and Wednesday, August 23, 1972) in the Before and After phases are shown on the following page. As can be seen, speed is reduced in all lanes in the gore area (compare Trap 1 to Trap 6). The reduction is about 5 to 7 mph with the greatest reduction in Lane 3. Curvature of the road for all lanes at the gore probably accounts for the reduction. After phase speeds were generally a mile or so faster. However, there are no marked differences in mean speed in the Before and After conditions. Local and nonlocal vehicles travel at about the same speed. Similar data resulted on the other paired Before/After days (Thursday, August 26, 1971 and Thursday, August 24, 1972).

INTERCHANGE 17 NORTH
GORE SIGN (BEFORE)
8/25/71
0930-1430

ABSOLUTE SPEED	TRAP 1			TRAP 2			TRAP 3			TRAP 4			TRAP 5			TRAP 6		
	TOTAL	LOCAL	NON-LOCAL	TOTAL	LOCAL	NON-LOCAL	TOTAL	LOCAL	NON-LOCAL	TOTAL	LOCAL	NON-LOCAL	TOTAL	LOCAL	NON-LOCAL	TOTAL	LOCAL	NON-LOCAL
LANE 1																		
N	2035	973	114	2001	937	104	1999	936	96	2039	955	92	2087	985	90	2130	1008	91
MEAN	59.57	59.49	59.25	59.74	59.40	59.75	59.33	59.08	60.51	58.62	58.52	59.30	57.42	57.34	58.22	55.93	55.95	56.58
STAND DEV	9.11	9.41	7.08	6.19	6.40	5.35	6.16	6.29	5.20	5.90	6.03	5.39	5.62	5.72	5.14	5.60	5.80	4.93
SKEWNESS	-1.88	-1.79	-1.97	-.93	-1.30	-.21	-1.14	-1.53	-.22	-.95	-1.56	-.35	-.61	-.80	-1.07	-.03	.40	-1.14
KURTOSIS	11.19	10.55	11.98	8.21	9.02	3.21	9.79	10.78	3.97	7.94	11.17	4.25	6.20	7.98	5.43	6.38	7.74	5.34
LANE 2																		
N	2731	1308	89	2734	1348	94	2735	1314	103	2667	1287	106	2612	1246	108	2526	1214	101
MEAN	58.62	58.80	59.50	58.65	58.77	59.48	57.61	57.62	58.26	56.79	56.82	57.34	54.38	54.45	54.77	51.47	51.56	51.70
STAND DEV	6.37	5.94	5.93	6.04	5.95	6.70	5.85	5.89	5.66	5.77	5.71	5.63	5.73	5.63	5.50	6.09	6.17	5.53
SKEWNESS	-1.06	-.48	-.06	-.72	-.56	-.92	-.64	-.91	-.02	-.15	-.25	-.15	-.18	-.29	-.17	-.63	-1.08	-.37
KURTOSIS	10.59	5.82	3.23	7.82	6.36	7.83	7.79	9.47	3.52	4.10	4.15	3.14	5.15	5.08	3.56	13.95	22.39	3.34
LANE 3																		
N	1965	924	69	1936	920	74	1997	955	73	2026	963	74	2032	974	74	2075	933	80
MEAN	62.48	62.75	61.76	63.45	63.73	63.02	62.47	62.68	61.94	61.05	61.17	60.53	58.23	58.29	57.23	55.29	55.47	54.10
STAND DEV	9.87	10.20	10.31	5.98	5.96	6.22	5.78	5.94	6.13	5.46	5.64	6.39	5.39	5.50	6.06	5.93	5.72	6.23
SKEWNESS	-2.35	-2.25	-2.41	-1.17	-.68	-.29	-1.39	-1.39	-.29	-.59	-.79	-.56	-.50	-.57	-.42	-1.02	-.36	-.52
KURTOSIS	13.23	12.43	11.66	10.25	5.13	3.08	12.43	11.83	2.84	5.67	6.56	3.28	4.95	5.14	2.85	10.97	4.85	3.52

INTERCHANGE 17 NORTH
GORE SIGN (AFTER)
8/23/72
1045-1430

ABSOLUTE SPEED	TRAP 1			TRAP 2			TRAP 3			TRAP 4			TRAP 5			TRAP 6		
	TOTAL	LOCAL	NON-LOCAL	TOTAL	LOCAL	NON-LOCAL	TOTAL	LOCAL	NON-LOCAL	TOTAL	LOCAL	NON-LOCAL	TOTAL	LOCAL	NON-LOCAL	TOTAL	LOCAL	NON-LOCAL
LANE 1																		
N	2453	1385	152	2391	1343	145	2381	1337	144	2402	1350	147	2408	1359	148	2409	1361	145
MEAN	60.97	61.07	61.09	60.96	61.17	60.53	59.44	60.70	59.80	60.50	60.82	59.38	58.02	58.26	57.23	55.85	56.01	55.39
STAND DEV	6.44	6.53	5.35	5.42	5.52	4.93	5.40	5.32	5.28	5.58	5.36	5.74	5.37	5.16	5.27	5.03	5.03	5.02
SKEWNESS	-.11	-.41	.29	-.28	-.32	-.32	-.24	-.11	-.31	-.49	-.22	-.38	-.74	-.35	.05	-.06	.07	.39
KURTOSIS	7.46	6.41	5.55	4.34	4.82	3.32	3.95	3.82	3.63	4.76	3.99	3.65	6.97	4.43	3.02	5.92	5.98	3.33
LANE 2																		
N	2346	1356	65	2412	1396	76	2442	1411	82	2405	1398	77	2396	1374	77	2380	1360	79
MEAN	58.28	58.27	57.04	58.53	59.71	58.09	58.80	58.90	57.99	57.78	57.87	57.42	55.90	55.97	55.43	53.76	53.39	53.31
STAND DEV	8.87	9.30	8.34	7.16	7.22	6.62	5.61	5.55	6.03	5.56	5.49	5.92	5.48	5.44	6.57	5.32	5.21	6.35
SKEWNESS	-1.32	-1.45	-1.20	-.88	-.99	-.05	-.08	-.08	-.41	.02	.05	-.02	-.21	-.31	-.42	-.11	-.10	-.49
KURTOSIS	9.59	9.73	5.76	8.01	8.40	3.02	3.81	3.89	4.75	3.78	4.03	3.26	4.74	5.84	3.49	3.64	3.61	3.83
LANE 3																		
N	2331	1252	128	2327	1254	123	2307	1245	119	2323	1255	121	2326	1260	120	2341	1272	121
MEAN	64.28	64.70	64.13	63.95	64.36	64.22	53.44	63.78	63.84	62.27	62.57	62.42	60.88	61.18	61.01	57.72	58.01	57.69
STAND DEV	5.11	5.00	4.57	5.07	4.84	4.33	5.03	4.91	4.57	5.11	5.08	5.12	5.15	5.07	4.89	5.21	5.08	5.20
SKEWNESS	-.22	-.11	-.41	-.35	.01	-.10	-.14	.05	-.02	-.21	-.17	-.43	-.37	-.24	-.03	-.13	-.13	.06
KURTOSIS	4.81	5.20	3.88	4.86	3.92	3.70	3.77	3.23	3.71	3.86	3.64	4.56	5.13	3.57	3.94	3.47	3.46	3.83

Tables on the following pages compare the proportions of vehicles meeting each of the criteria of speed differences, hazardous maneuvers, etc. for matched data in the Before and After conditons. Appropriate annotations are provided beneath each table.

In the final set of tables, vehicles that actually exited onto I-70S are separated from those continuing on I-495. Lane usage across the three lanes instrumented indicates a dramatic improvement in the After phase.

INTERCHANGE 17 NORTH
GORE SIGN (BEFORE)
8/25/71
0930-1430

INTERCHANGE 17 NORTH
GORE SIGN (AFTER)
8/23/72
1045-1430

		AUTOS	AUTOS		NONAUTOS	NONAUTOS		ALL	ALL	
		6167	6617		564	513		6731	7130	
1.	SPEED DIFFERENCE	.19183 .00983	.15898 .00881	↓	.29078 .03748	.28460 .03905	N.S.	.20012 .00956	.16802 .00868	↓
2.	HEADWAY VIOLATION	.11772 .00804	.14357 .00845	↑	.08688 .02325	.08382 .02398	N.S.	.11514 .00763	.13927 .00804	↑
3.	HAZARDOUS MANUEVERS	.03730 .00473	.01451 .00288	↓	.02128 .01191	.01365 .01004	N.S.	.03595 .00445	.01445 .00277	↓
4.	1 + 2	.08983 .00714	.10035 .00724	↑	.11879 .02670	.08967 .02472	N.S.	.09226 .00691	.09958 .00695	N.S.
5.	2 + 3	.02011 .00350	.00680 .00198	↓	.00532 .00600	.00195 .00382	N.S.	.01887 .00325	.00645 .00186	↓
6.	1 + 3	.04329 .00508	.01194 .00262	↓	.04078 .01632	.01559 .01072	↓	.04308 .00485	.01220 .00255	↓
7.	1 + 2 + 3	.02611 .00398	.01194 .00262	↓	.03191 .01451	.00975 .00850	↓	.02659 .00384	.01178 .00250	↓
8.	NORMAL	.47381 .01246	.55191 .01198	↑	.40426 .04050	.50097 .04327	↑	.46798 .01192	.54825 .01155	↑
9.	DBL LANE CHANGES	.08675 .00703	.01043 .00245	↓	.09752 .02448	.00780 .00761	↓	.08765 .00676	.01024 .00234	↓

Most criteria indicate a significant improvement in the After condition. The proportion of autos performing hazardous maneuvers has dropped from .12681 (3+5+6+7) to .04519. Fewer autos are traveling at speeds of 5 mph or more slower than the mean speed. However, there are more headway violations. Significantly more vehicles meet none of the criteria (i.e., the normal category). The proportion of nonautos performing hazardous maneuvers has dropped from .09929 to .04094. However, fewer significant differences are found for nonautos.

		INTERCHANGE 17 NORTH GORE SIGN (BEFORE) 8/26/71 0930-1430		INTERCHANGE 17 NORTH GORE SIGN (AFTER) 8/24/72 0930-1430			
		AUTOS	AUTOS	NONAUTOS	NONAUTOS	ALL	ALL
		8010	9135	639	660	8649	9795
1.	SPEED DIFFERENCE	.17778 .00837	.15862 .00749 ↓	.32864 .03642	.28333 .03438 N.S.	.18892 .00825	.16702 .00739 ↓
2.	HEADWAY VIOLATION	.14682 .00775	.13519 .00701 ↓	.10798 .02406	.10303 .02319 N.S.	.14395 .00740	.13303 .00673 ↓
3.	HAZARDOUS MANUEVERS	.02347 .00332	.01620 .00259 ↓	.00626 .00612	.00152 .00297 N.S.	.02220 .00311	.01521 .00242 ↓
4.	1 + 2	.10774 .00679	.09009 .00587 ↓	.07981 .02101	.08030 .02073 N.S.	.10568 .00648	.08943 .00565 ↓
5.	2 + 3	.01211 .00240	.00799 .00183 ↓	.00782 .00683	.00152 .00297 N.S.	.01179 .00228	.00755 .00171 ↓
6.	1 + 3	.01985 .00305	.01138 .00218 ↓	.02660 .01248	.01970 .01060 N.S.	.02035 .00298	.01194 .00215 ↓
7.	1 + 2 + 3	.02272 .00326	.01007 .00205 ↓	.02347 .01174	.00606 .00592 ↓	.02278 .00314	.00980 .00195 ↓
8.	NORMAL	.48951 .01095	.57044 .01015 ↑	.41941 .03826	.50455 .03814 ↑	.48433 .01053	.56600 .00982 ↑
9.	DBL LANE CHANGES	.04432 .00451	.01171 .00221 ↓	.06886 .01963	.00303 .00419 ↓	.04613 .00442	.01113 .00208 ↓

The Thursday data are similar to those shown previously for Wednesday. For autos, all criteria indicate a significant improvement under the diagrammatic signing conditions. A tendency for a similar reduction in hazardous maneuvers, etc. is seen for nonautos but most differences do not reach the .05 level of significance. For nonautos, however, the proportion falling into the normal category is significantly higher in the After phase.

INTERCHANGE 17 NORTH
GORE SIGN (BEFORE)
8/25/71
0930-1430

INTERCHANGE 17 NORTH
GORE SIGN (AFTER)
8/23/72
1045-1430

	LOCAL	LOCAL	FOREIGN	FOREIGN	ALL	ALL
	3205	3993	272	345	3477	4338
1. SPEED DIFFERENCE	.20187 .01390	.15778 .01131 ↓	.16176 .04376	.17391 .04000 N.S.	.19873 .01326	.15906 .01088 ↓
2. HEADWAY VIOLATION	.11700 .01113	.14450 .01091 ↑	.10294 .03611	.08696 .02973 N.S.	.11590 .01064	.13993 .01032 ↑
3. HAZARDOUS MANUEVERS	.03588 .00644	.01427 .00368 ↓	.06985 .03029	.02319 .01588 ↓	.03854 .00640	.01498 .00362 ↓
4. 1 + 2	.09048 .00993	.10468 .00950 ↑	.05515 .02713	.07536 .02786 N.S.	.08772 .00940	.10235 .00902 ↑
5. 2 + 3	.02246 .00513	.00676 .00254 ↓	.01838 .01596	.01159 .01130 N.S.	.02215 .00489	.00715 .00251 ↓
6. 1 + 3	.03931 .00673	.01027 .00313 ↓	.05882 .02796	.02029 .01488 ↓	.04084 .00658	.01107 .00311 ↓
7. 1 + 2 + 3	.02902 .00581	.01102 .00324 ↓	.02206 .01745	.01449 .01261 N.S.	.02847 .00553	.01130 .00314 ↓
8. NORMAL	.46396 .01727	.55071 .01543 ↑	.51103 .05941	.59420 .05182 ↑	.46764 .01658	.55417 .01479 ↑
9. DBL LANE CHANGES	.08643 .00973	.00877 .00289 ↓	.09926 .03554	.01449 .01261 ↓	.08743 .00939	.00922 .00284 ↓

Changes in the local vehicle population are similar to those seen for the total population in previous tables. The smaller population of foreign vehicles probably accounts for fewer significant differences. An approximate three-fold decrease in total hazardous maneuvers (3+5+6+7) was found (from .16911 Before to .06956 After). A similar drop was found for the population as a whole on the same day (.12449 Before to .04488 After summed under ALL vehicles in the AUTO/NONAUTO stratification which includes the entire population on the same day).

INTERCHANGE 17 NORTH
GORE SIGN (AFTER)
8/23/72
1045-1430

EXIT TRAFFIC 4721	TRAP 1	2	3	4	5	6
1 N	.0267 .0046	.0157 .0035	.0089 .0027	.0038 .0018	.0017 .0012	0.0000 0.0000
1 HV	.0036 .0017	.0019 .0012	.0011 .0009	.0008 .0008	.0002 .0004	0.0000 0.0000
1 LS	.0163 .0036	.0117 .0031	.0076 .0025	.0034 .0017	.0013 .0010	0.0000 0.0000
1 HV+LS	.0051 .0020	.0019 .0012	.0013 .0010	.0004 .0006	.0004 .0006	0.0000 0.0000
2 N	.3415 .0135	.3609 .0137	.3821 .0139	.3874 .0139	.3970 .0139	.3914 .0139
2 HV	.0358 .0053	.0313 .0050	.0360 .0053	.0345 .0052	.0373 .0054	.0364 .0053
2 LS	.0743 .0075	.0794 .0077	.0646 .0070	.0684 .0072	.0695 .0073	.0655 .0071
2 HV+LS	.0148 .0034	.0114 .0030	.0136 .0033	.0153 .0035	.0117 .0031	.0108 .0029
3 N	.3561 .0137	.3607 .0137	.3561 .0137	.3580 .0137	.3569 .0137	.3540 .0136
3 HV	.0676 .0072	.0686 .0072	.0682 .0072	.0703 .0073	.0718 .0074	.0714 .0073
3 LS	.0398 .0056	.0366 .0054	.0392 .0055	.0432 .0058	.0447 .0059	.0517 .0063
3 HV+LS	.0184 .0038	.0197 .0040	.0214 .0041	.0184 .0038	.0176 .0037	.0189 .0039

Before
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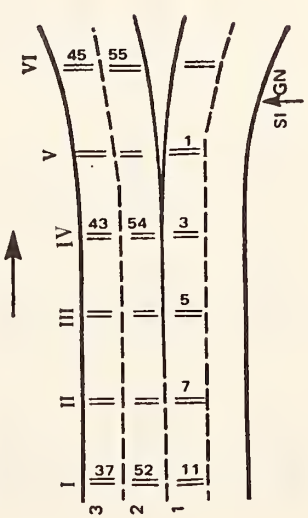

After
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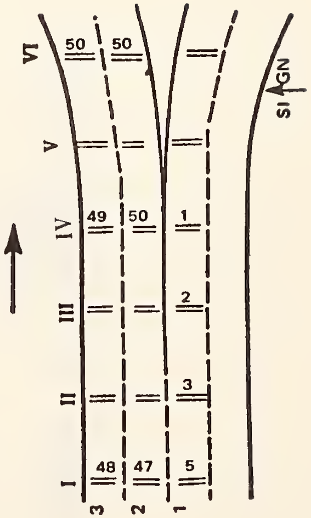

TOTALS LANE 1	.0517 .0063 ↓	.0311 .0050 ↓	.0189 .0039 ↓	.0085 .0026 ↓	.0036 .0017 ↓	0.0000 0.0000
TOTALS LANE 2	.4664 .0142	.4832 .0143	.4963 .0143	.5016 .0143	.5054 .0143	.5041 .0143
TOTALS LANE 3	.4819 .0143	.4857 .0143	.4849 .0143	.4899 .0143	.4910 .0143	.4959 .0143

This and the data on the following page show lane placement of exiting vehicles on Wednesday in the Before and After phases. All exiting traffic must be in Lanes 2 or 3 at Trap 6 because a guardrail in the gore at that location prohibits further movements from Lane 1 into Lanes 2 or 3. The above diagram shows that whereas 11% of the traffic exiting onto I-70S in the Before phase (the data are drawn from the following page) entered the array in Lane 1, only 5% entered the array in this lane in the After phase. The reduction in the proportions of exiting vehicles using Lane 1 in the After phase is significant at the .05 level or better. It will also be noted that the exiting traffic is more evenly distributed across Lanes 2 and 3 in the After phase.

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                        INTERCHANGE 17 NORTH
                        GORE SIGN  (BEFORE)
                        8/25/71
                        0930-1430

EXIT TRAFFIC                             TRAP
   4601                 1       2       3       4       5       6

           1 N        .0652   .0372   .0289   .0137   .0039  0.0000
                      .0071   .0055   .0048   .0034   .0018  0.0000

           1 HV       .0124   .0039   .0007   .0009   .0007  0.0000
                      .0032   .0018   .0007   .0009   .0007  0.0000

           1 LS       .0298   .0267   .0183   .0111   .0035  0.0000
                      .0049   .0047   .0039   .0030   .0017  0.0000

           1 HV+LS    .0046   .0013   .0017   .0007   .0002  0.0000
                      .0019   .0010   .0012   .0007   .0004  0.0000

           2 N        .3810   .4147   .4186   .4219   .4347   .4123
                      .0140   .0142   .0143   .0143   .0143   .0142

           2 HV       .0419   .0302   .0215   .0222   .0211   .0300
                      .0058   .0049   .0042   .0043   .0042   .0049

           2 LS       .0863   .0837   .0839   .0865   .0895   .0928
                      .0081   .0080   .0080   .0081   .0083   .0084

           2 HV+LS    .0102   .0076   .0120   .0126   .0091   .0139
                      .0029   .0025   .0031   .0032   .0027   .0034

           3 N        .2699   .3078   .3325   .3369   .3384   .3312     TOTALS    .1119   .0691   .0496   .0263   .0083  0.0000
                      .0128   .0133   .0136   .0137   .0137   .0136     LANE 1    .0091   .0073   .0063   .0046   .0026  0.0000

           3 HV       .0387   .0241   .0233   .0261   .0276   .0380     TOTALS    .5195   .5362   .5360   .5431   .5544   .5490
                      .0056   .0044   .0044   .0046   .0047   .0055     LANE 2    .0144   .0144   .0144   .0144   .0144   .0144

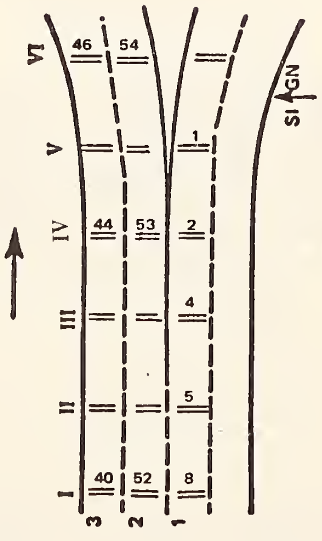
           3 LS       .0478   .0541   .0495   .0556   .0589   .0652     TOTALS    .3686   .3947   .4145   .4306   .4373   .4510
                      .0062   .0065   .0062   .0066   .0068   .0071     LANE 3    .0139   .0141   .0142   .0143   .0143   .0144

           3 HV+LS    .0122   .0087   .0102   .0120   .0124   .0165
                      .0032   .0027   .0029   .0031   .0032   .0037
```

INTERCHANGE 17 NORTH
GORE SIGN (AFTER)
8/24/72
0930-1430

EXIT TRAFFIC 6581	TRAP 1	2	3	4	5	6
1 N	.0214 .0035	.0120 .0026	.0079 .0021	.0044 .0016	.0005 .0005	0.0000 0.0000
1 HV	.0027 .0013	.0020 .0011	.0011 .0008	.0005 .0005	.0002 .0003	0.0000 0.0000
1 LS	.0103 .0024	.0074 .0021	.0061 .0019	.0033 .0014	.0009 .0007	0.0000 0.0000
1 HV+LS	.0015 .0009	.0014 .0009	.0008 .0007	.0002 .0003	.0002 .0003	0.0000 0.0000
2 N	.3794 .0117	.3926 .0118	.3840 .0118	.3898 .0118	.3919 .0118	.3881 .0118
2 HV	.0418 .0048	.0416 .0048	.0412 .0048	.0375 .0046	.0377 .0046	.0353 .0045
2 LS	.0658 .0060	.0611 .0058	.0658 .0060	.0653 .0060	.0702 .0062	.0737 .0063
2 HV+LS	.0115 .0026	.0097 .0024	.0109 .0025	.0119 .0026	.0102 .0024	.0123 .0027
3 N	.3468 .0115	.3477 .0115	.3563 .0116	.3636 .0116	.3613 .0116	.3580 .0116
3 HV	.0623 .0058	.0656 .0060	.0672 .0060	.0638 .0059	.0655 .0060	.0653 .0060
3 LS	.0395 .0047	.0415 .0048	.0397 .0047	.0406 .0048	.0444 .0050	.0500 .0053
3 HV+LS	.0169 .0031	.0173 .0032	.0191 .0033	.0191 .0033	.0172 .0031	.0173 .0032

Before
%



After
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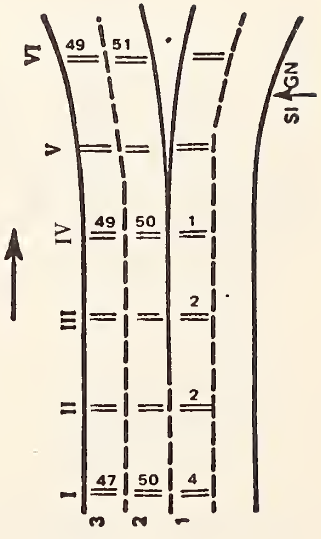


TOTALS LANE 1	.0360 .0045 ↓	.0228 .0036 ↓	.0158 .0030 ↓	.0084 .0022 ↓	.0017 .0010 ↓	0.0000 0.0000
TOTALS LANE 2	.4986 .0121	.5051 .0121	.5019 .0121	.5045 .0121	.5100 .0121	.5093 .0121
TOTALS LANE 3	.4654 .0121	.4721 .0121	.4823 .0121	.4872 .0121	.4884 .0121	.4907 .0121

The data collected on Thursday in the Before and After phases (presented on this and the following page) confirms the Wednesday results. A significantly lower proportion of exiting traffic is found in Lane 1 at all traps under the diagrammatic signing condition. The exiting traffic is also more evenly distributed in Lanes 2 and 3 in the After phase.

```
                    INTERCHANGE 17 NORTH
                    GORE SIGN  (BEFORE)
                    8/26/71
                    0930-1430

EXIT TRAFFIC                          TRAP
   5897               1       2       3       4       5       6

          1 N       .0402   .0293   .0214   .0129   .0090  0.0000
                    .0050   .0043   .0037   .0029   .0024  0.0000

          1 HV      .0171   .0039   .0017   .0020   .0012  0.0000
                    .0033   .0016   .0011   .0012   .0009  0.0000

          1 LS      .0173   .0161   .0125   .0078   .0036  0.0000
                    .0033   .0032   .0028   .0022   .0015  0.0000

          1 HV+LS   .0066   .0029   .0025   .0012  0.0000  0.0000
                    .0021   .0014   .0013   .0009  0.0000  0.0000

          2 N       .3821   .3868   .3949   .4000   .4104   .4173
                    .0124   .0124   .0125   .0125   .0126   .0126

          2 HV      .0356   .0397   .0393   .0383   .0356   .0368
                    .0047   .0050   .0050   .0049   .0047   .0048

          2 LS      .0836   .0853   .0785   .0799   .0802   .0731
                    .0071   .0071   .0069   .0069   .0069   .0066

          2 HV+LS   .0139   .0132   .0137   .0149   .0158   .0142
                    .0030   .0029   .0030   .0031   .0032   .0030

          3 N       .2740   .3236   .3305   .3324   .3303   .3239   TOTALS   .0812   .0522   .0382   .0239   .0137  0.0000
                    .0114   .0119   .0120   .0120   .0120   .0119   LANE 1   .0070   .0057   .0049   .0039   .0030  0.0000

          3 HV      .0672   .0419   .0431   .0424   .0456   .0446   TOTALS   .5152   .5250   .5265   .5332   .5420   .5415
                    .0064   .0051   .0052   .0051   .0053   .0053   LANE 2   .0128   .0127   .0127   .0127   .0127   .0127

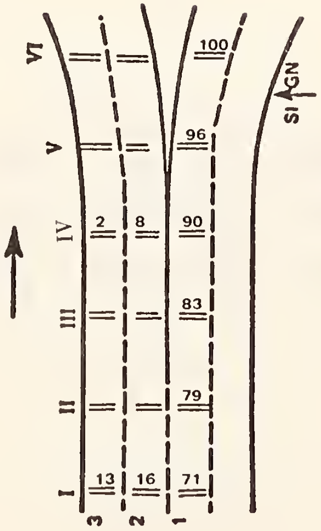
          3 LS      .0424   .0432   .0460   .0509   .0521   .0675   TOTALS   .4036   .4228   .4353   .4429   .4443   .4585
                    .0051   .0052   .0053   .0056   .0057   .0064   LANE 3   .0125   .0126   .0127   .0127   .0127   .0127

          3 HV+LS   .0200   .0141   .0158   .0173   .0163   .0226
                    .0036   .0030   .0032   .0033   .0032   .0038
```

INTERCHANGE 17 NORTH
GORE SIGN (AFTER)
8/23/72
1045-1430

THRU TRAFFIC 2409	TRAP 1	2	3	4	5	6
1 N	.6758 .0187	.6953 .0184	.7086 .0181	.7406 .0175	.7572 .0171	.7588 .0171
1 HV	.1054 .0123	.1042 .0122	.1117 .0126	.1009 .0120	.1038 .0122	.1079 .0124
1 LS	.0917 .0115	.0909 .0115	.0922 .0116	.0955 .0117	.0963 .0118	.1063 .0123
1 HV+LS	.0440 .0082	.0411 .0079	.0399 .0077	.0436 .0082	.0353 .0074	.0270 .0065
2 N	.0403 .0079	.0386 .0077	.0299 .0058	.0108 .0041	.0029 .0021	0.0000 0.0000
2 HV	.0050 .0028	.0037 .0024	.0029 .0021	.0008 .0012	0.0000 0.0000	0.0000 0.0000
2 LS	.0125 .0044	.0100 .0040	.0066 .0032	.0033 .0023	.0008 .0012	0.0000 0.0000
2 HV+LS	.0021 .0019	.0021 .0018	.0017 .0016	.0004 .0008	.0004 .0008	0.0000 0.0000
3 N	.0158 .0050	.0116 .0043	.0062 .0031	.0037 .0024	.0025 .0020	0.0000 0.0000
3 HV	.0025 .0020	.0008 .0012	0.0000 0.0000	.0004 .0008	.0004 .0008	0.0000 0.0000
3 LS	.0037 .0024	.0012 .0014	.0004 .0008	0.0000 0.0000	.0004 .0008	0.0000 0.0000
3 HV+LS	.0012 .0014	.0004 .0009	.0008 .0012	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

Before
%



After
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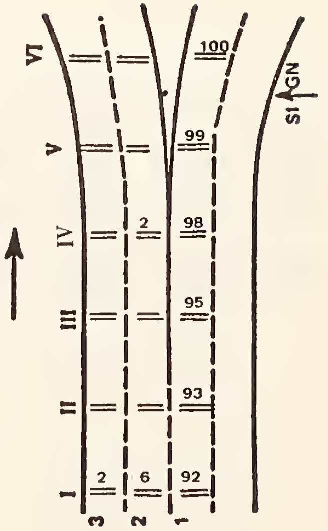

TOTALS LANE 1	.9170 .0110	.9315 .0101	.9514 .0086	.9805 .0055	.9925 .0034	1.0000 0.0000
TOTALS LANE 2	.0598 .0095	.0544 .0091	.0411 .0079	.0154 .0049	.0042 .0026	0.0000 0.0000
TOTALS LANE 3	.0232 .0060	.0141 .0047	.0075 .0034	.0042 .0026	.0033 .0023	0.0000 0.0000

An even more dramatic improvement in lane placement for through traffic than for exiting traffic was found in the After phase. As shown above, 92% of the traffic continuing on I-495 entered in Lane 1 in the After phase whereas only 71% entered the array in this lane on the matched day in the Before phase. Other comparisons may be drawn by the reader. If the equivalent Totals table of Before data on the next page is compared to the table at right above, all proportions are significantly different by inspection at the .05 level or better (Case I situations—see Measures of Effectiveness, Chapter V).

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                       INTERCHANGE 17 NORTH
                       GORE SIGN  (BEFORE)
                       9/25/71
                       0930-1430

THRU TRAFFIC                                 TRAP
   2130                  1         2         3         4         5         6

           1 N         .5136     .6089     .6474     .6746     .7268     .7310
                       .0212     .0207     .0203     .0199     .0189     .0188

           1 HV        .0850     .0554     .0488     .0563     .0624     .0869
                       .0118     .0097     .0092     .0093     .0103     .0120

           1 LS        .0887     .1056     .1150     .1399     .1493     .1540
                       .0121     .0131     .0135     .0147     .0151     .0153

           1 HV+LS     .0263     .0202     .0202     .0291     .0235     .0282
                       .0068     .0060     .0060     .0071     .0064     .0070

           2 N         .1150     .1099     .0901     .0531     .0174    0.0000
                       .0135     .0133     .0122     .0095     .0055    0.0000

           2 HV        .0178     .0122     .0070     .0047     .0028    0.0000
                       .0056     .0047     .0036     .0029     .0023    0.0000

           2 LS        .0225     .0254     .0254     .0183     .0085    0.0000
                       .0063     .0067     .0067     .0057     .0039    0.0000

           2 HV+LS     .0047     .0061     .0038     .0028    0.0000    0.0000
                       .0029     .0033     .0026     .0023    0.0000    0.0000

           3 N         .0729     .0408     .0310     .0136     .0056    0.0000     TOTALS     .7136     .7901     .8315     .9000     .9620    1.0000
                       .0110     .0084     .0074     .0049     .0032    0.0000     LANE 1     .0192     .0173     .0159     .0127     .0081    0.0000

           3 HV        .0183     .0033     .0014     .0005     .0014    0.0000     TOTALS     .1601     .1535     .1263     .0789     .0286    0.0000
                       .0057     .0024     .0016     .0009     .0016    0.0000     LANE 2     .0156     .0153     .0141     .0114     .0071    0.0000

           3 LS        .0239     .0198     .0094     .0066     .0019    0.0000     TOTALS     .1263     .0563     .0423     .0211     .0094    0.0000
                       .0065     .0044     .0041     .0034     .0018    0.0000     LANE 3     .0141     .0098     .0085     .0061     .0041    0.0000

           3 HV+LS     .0113     .0014     .0005     .0005     .0005    0.0000
                       .0045     .0016     .0009     .0009     .0009    0.0000
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                    INTERCHANGE 17 NORTH
                    GORE SIGN  (AFTER)
                    8/24/72
                    0930-1430

THRU TRAFFIC                                 TRAP
   3214                   1        2        3        4        5        6

        1 N             .6658    .6864    .7181    .7380    .7461    .7511
                        .0163    .0160    .0156    .0152    .0150    .0149

        1 HV            .0943    .0893    .0965    .0933    .0993    .1052
                        .0101    .0099    .0102    .0101    .0103    .0106

        1 LS            .0965    .1045    .0927    .0955    .1086    .1164
                        .0102    .0106    .0100    .0102    .0108    .0111

        1 HV+LS         .0401    .0352    .0373    .0426    .0376    .0274
                        .0068    .0064    .0066    .0070    .0066    .0056

        2 N             .0597    .0523    .0324    .0156    .0037   0.0000
                        .0082    .0077    .0061    .0043    .0021   0.0000

        2 HV            .0081    .0047    .0040    .0034    .0009   0.0000
                        .0031    .0024    .0022    .0020    .0011   0.0000

        2 LS            .0109    .0078    .0072    .0050    .0025   0.0000
                        .0036    .0030    .0029    .0024    .0017   0.0000

        2 HV+LS         .0028    .0022    .0006    .0009   0.0000   0.0000
                        .0018    .0016    .0009    .0011   0.0000   0.0000

        3 N             .0146    .0124    .0078    .0040    .0009   0.0000
                        .0042    .0038    .0030    .0022    .0011   0.0000

        3 HV            .0028    .0025    .0019    .0003   0.0000   0.0000
                        .0018    .0017    .0015    .0006   0.0000   0.0000

        3 LS            .0037    .0028    .0016    .0012    .0003   0.0000
                        .0021    .0018    .0014    .0012    .0006   0.0000

        3 HV+LS         .0066   0.0000   0.0000   0.0000   0.0000   0.0000
                        .0069   0.0000   0.0000   0.0000   0.0000   0.0000
```
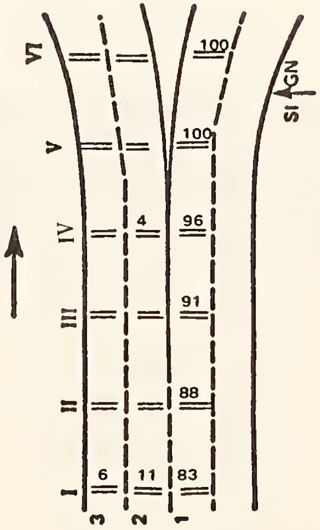
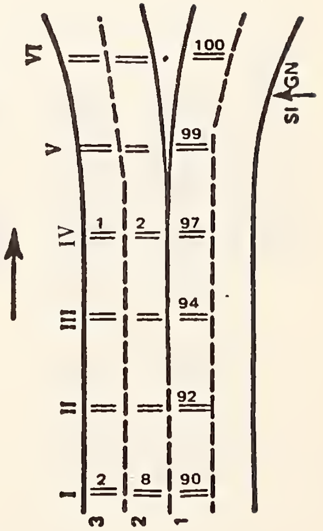

Before
%



After
%



```
TOTALS        .8967    .9154    .9446    .9695    .9916   1.0000
LANE 1        .0105    .0096    .0079    .0059    .0032   0.0000

TOTALS        .0815    .0669    .0442    .0249    .0072   0.0000
LANE 2        .0095    .0086    .0071    .0054    .0029   0.0000

TOTALS        .0218    .0177    .0112    .0056    .0012   0.0000
LANE 3        .0050    .0046    .0036    .0026    .0012   0.0000
```

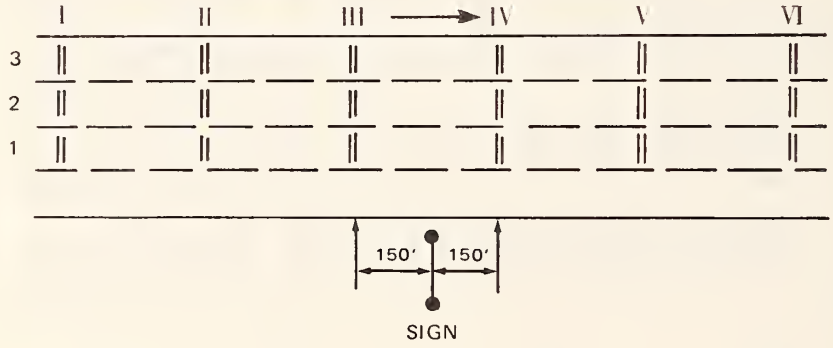
Lane placement for through vehicles collected on Thursdays in the Before and After phases confirms that found on Wednesday although the differences are not as dramatic. Proportions in the first four traps for Lanes 1 and 2 and the first two traps for Lane 3 are significantly different. Lane usage by through vehicles is clearly improved in the diagrammatic signing condition.

```
                     INTEPCHANGE 17 NORTH
                     GORE SIGN  (BFFORE)
                     8/26/71
                     0930-1430

THRU TPAFFIC                            TRAP
   2752                 1       2       3       4       5       6

           1 N        .5625   .6646   .6911   .7100   .7355   .7002
                      .0185   .0176   .0173   .0170   .0165   .0171

           1 HV       .1435   .0810   .0767   .0872   .0890   .1094
                      .0131   .0102   .0099   .0105   .0106   .0117

           1 LS       .0850   .1014   .1119   .1239   .1395   .1403
                      .0104   .0113   .0118   .0123   .0129   .0130

           1 HV+LS    .0367   .0294   .0316   .0389   .0360   .0501
                      .0070   .0063   .0065   .0072   .0070   .0082

           2 N        .0832   .0785   .0531   .0243  0.0000  0.0000
                      .0103   .0100   .0084   .0058  0.0000  0.0000

           2 HV       .0109   .0105   .0062   .0022  0.0000  0.0000
                      .0039   .0038   .0029   .0017  0.0000  0.0000

           2 LS       .0113   .0102   .0149   .0102  0.0000  0.0000
                      .0039   .0037   .0045   .0037  0.0000  0.0000

           2 HV+LS    .0036   .0040   .0033   .0007  0.0000  0.0000
                      .0022   .0024   .0021   .0010  0.0000  0.0000

           3 N        .0316   .0142   .0062   .0007  0.0000  0.0000     TOTALS  .8278   .8765   .9113   .9600  1.0000  1.0000
                      .0065   .0044   .0029   .0010  0.0000  0.0000     LANE 1  .0141   .0123   .0106   .0073  0.0000  0.0000

           3 HV       .0105   .0011   .0011   .0004  0.0000  0.0000     TOTALS  .1090   .1032   .0774   .0374  0.0000  0.0000
                      .0038   .0012   .0012   .0007  0.0000  0.0000     LANE 2  .0116   .0114   .0100   .0071  0.0000  0.0000

           3 LS       .0149   .0044   .0036   .0015  0.0000  0.0000     TOTALS  .0632   .0203   .0113   .0025  0.0000  0.0000
                      .0045   .0025   .0022   .0014  0.0000  0.0000     LANE 3  .0091   .0053   .0039   .0019  0.0000  0.0000

           3 HV+LS    .0062   .0007   .0004  0.0000  0.0000  0.0000
                      .0029   .0010   .0007  0.0000  0.0000  0.0000
```

To summarize the results at the gore of Interchange 17 North, the diagrammatic signs were associated with a significant improvement in driver performance. The proportion of vehicles traveling at least 5 mph below the mean speed was reduced for the population as a whole and for subpopulations of significant size (autos and vehicles with local plates). Significant and sizable reductions in erratic maneuvers were found. Significant reductions in double lane changes were found for the population as a whole and all subpopulations. Headway violation results were mixed. The proportions of vehicles meeting none of the criteria of poor performance (speed differences, headway violations, hazardous maneuvers and combinations of these) increased for the population as a whole and for all subpopulations. Lane usage by both exiting and through traffic, especially the latter category, was significantly bettered in the After phase.

Attention is now turned to the exit direction and advance signing locations. In view of the reduction in erratic maneuvers and improved vehicle placement at the gore, significant increases in preparatory and through maneuvers at one or both of these locations would be expected, provided the tapeswitch array was extensive enough to detect such changes.

Exit Direction (G-1) Sign. Tapeswitch instrumentation paralleled that at the gore. In other words, the right or shoulder-most lane was not instrumented. As at all pregore signing locations, the switches were deployed symmetrically about the sign. Thus, the first trap was located 750 feet upstream from the sign while the last or sixth trap was located 750 feet downstream from the sign. Tapeswitch instrumentation is shown diagrammatically below.



The average hourly percent of traffic using each of the three instrumented lanes at the first, fourth and sixth traps during the two Before phase and the two After phase data collection days was as shown below:

		Before		After	
		9/22/71	9/23/71	9/20/72	9/21/72
Trap 1	Lane 1	38.3	39.2	31.2	33.8
	Lane 2	32.2	28.3	42.1	40.5
	Lane 3	29.5	32.5	26.6	25.7
Trap 4	Lane 1	38.0	37.8	32.0	34.3
	Lane 2	34.0	30.6	39.3	37.5
	Lane 3	28.0	31.6	28.7	28.2
Trap 6	Lane 1	41.5	40.3	35.7	37.4
	Lane 2	31.8	29.8	36.9	34.6
	Lane 3	26.7	29.9	28.0	27.9

Of the three instrumented lanes, Lane 3 is somewhat less heavily traveled than Lanes 1 and 2.

Vehicular speeds remained relatively constant as the array was traversed from Trap 1 through Trap 6. The ranges in mean speed by lane measured across all four data collection days (at Trap 6) was as shown below:

Lane	Range In Mean Speed
1	57-61
2	57-59
3	60-65

Thus, the highest mean speed was generally found in instrumented Lane 3, the lane closest to the median, as might be expected.

The tables on the following pages show the proportions of vehicles performing preparatory, through and other lane changing maneuvers as well as the proportions of vehicles meeting the previously defined criteria for speed differences, headway violations, double lane changes and various combinations of these. The last tables in the set show the lane usage by vehicles in the Before and After phases.

Concerning preparatory and through maneuvers, it will be remembered that these are defined in terms of eventual behavior at the gore. "Preparatory" signifies preparation for exiting; "through" signifies a maneuver which a vehicle might make if it were planning to continue in the through traffic lanes at the gore. For this left exit, major fork interchange (and restricting attention to the three instrumented lanes) a preparatory maneuver is a movement from Lane 1 to Lanes 2 or 3. A through maneuver is a movement from Lanes 2 or 3 to Lane 1. Other lane changes are movements from Lane 2 to Lane 3 and vice versa.

INTERCHANGE 17 NORTH
ADVANCE (G-1) SIGN (BEFORE)
9/22/71
0930-1430

INTERCHANGE 17 NORTH
ADVANCE (G-1) SIGN (AFTER)
9/20/72
0930-1430

		AUTOS	AUTOS	NONAUTOS	NONAUTOS	ALL	ALL
		6180	7183	392	630	6572	7813
1.	PREP. MANEUVERS	.06440 .00612	.04747 .00492 ↓	.15561 .03588	.04603 .01636 ↓	.06984 .00616	.04736 .00471 ↓
2.	THROUGH MANEUVERS	.09482 .00730	.08478 .00644 ↓	.07143 .02550	.02857 .01301 ↓	.09343 .00704	.08025 .00602 ↓
3.	OTHER LANE CHANGES	.06181 .00600	.04093 .00458 ↓	.04592 .02072	.02698 .01265 N.S.	.06086 .00578	.03981 .00434 ↓
4.	NO LANE CHANGES	.77896 .01035	.82681 .00875 ↑	.72704 .04410	.89841 .02359 ↑	.77587 .01008	.83259 .00828 ↑
1.	SPEED DIFFERENCE	.21812 .01030	.08604 .00648 ↓	.38520 .04818	.21429 .03204 ↓	.22809 .01014	.09638 .00654 ↓
2.	HEADWAY VIOLATION	.12702 .00830	.17012 .00869 ↑	.08673 .02786	.11905 .02529 N.S.	.12462 .00799	.16601 .00825 ↑
3.	DBL LANE CHANGES	.01019 .00250	.01629 .00293 ↑	.00255 .00499	0.00000 0.00000	.00974 .00237	.01498 .00269 ↑
4.	1 + 2	.09013 .00714	.04121 .00460 ↓	.11480 .03156	.03333 .01402 ↓	.09160 .00697	.04057 .00437 ↓
5.	2 + 3	.00453 .00167	.00710 .00194	0.00000 0.00000	0.00000 0.00000	.00426 .00157	.00653 .00179
6.	1 + 3	.00518 .00179	.00292 .00125	.00255 .00499	0.00000 0.00000	.00502 .00171	.00269 .00115
7.	1 + 2 + 3	.00599 .00192	.00181 .00098	.00510 .00705	.00159 .00311	.00593 .00186	.00179 .00094
8.	NORMAL	.53883 .01243	.67451 .01084 ↑	.40306 .04856	.63175 .03766 ↑	.53074 .01207	.67106 .01042 ↑

Preparatory, through and other lane changes are significantly reduced in the After phase. The proportion of vehicles performing no lane changes is significantly increased for the Wednesday data. While the proportion of vehicles proceeding at 5 mph or more less than the mean speed for all vehicles is significantly reduced in the After phase, headway violations and double lane changes were significantly increased. The proportion of vehicles meeting the criterion of "normal" (that is, not showing speed differences, headway violations, or performing double lane changes) is significantly increased.

INTERCHANGE 17 NORTH
ADVANCE (G-1) SIGN (BEFORE)
9/23/71
0930-1430

INTERCHANGE 17 NORTH
ADVANCE (G-1) SIGN (AFTER)
9/21/72
0930-1430

		AUTOS	AUTOS		NONAUTOS	NONAUTOS		ALL	ALL	
		5809	6005		323	614		6132	6619	
1.	PREP. MANUEVERS	.07970 .00696	.07577 .00669	N.S.	.18885 .04268	.06515 .01952	↓	.08545 .00700	.07478 .00634	↓
2.	THROUGH MANUEVERS	.08797 .00728	.10075 .00761	↑	.04025 .02143	.03583 .01470	N.S.	.08545 .00700	.09473 .00705	N.S.
3.	OTHER LANE CHANGES	.06180 .00619	.05079 .00555	↓	.06192 .02628	.02280 .01181	↓	.06181 .00603	.04819 .00516	↓
4.	NO LANE CHANGES	.77053 .01081	.77269 .01060	N.S.	.70898 .04954	.87622 .02605	↑	.76729 .01058	.78229 .00994	↑
1.	SPEED DIFFERENCE	.20640 .01041	.12406 .00834	↓	.36842 .05261	.27199 .03520	↓	.21494 .01028	.13779 .00830	↓
2.	HEADWAY VIOLATION	.11878 .00832	.13389 .00861	↑	.08050 .02967	.09935 .02366	N.S.	.11676 .00804	.13068 .00812	↑
3.	DBL LANE CHANGES	.01377 .00300	.02415 .00388	↑	.00619 .00855	.00326 .00451	N.S.	.01337 .00287	.02221 .00355	↑
4.	1 + 2	.09072 .00739	.05279 .00566	↓	.13932 .03776	.07166 .02040	↓	.09328 .00728	.05454 .00547	↓
5.	2 + 3	.00568 .00193	.01099 .00264	↑	.00619 .00855	.00326 .00451	N.S.	.00571 .00189	.01027 .00243	↑
6.	1 + 3	.00551 .00190	.00949 .00245	↑	.01238 .01206	.00163 .00319	N.S.	.00587 .00191	.00876 .00225	↑
7.	1 + 2 + 3	.00499 .00181	.00583 .00193	N.S.	0.00000 0.00000	.00326 .00451		.00473 .00172	.00559 .00180	N.S.
8.	NORMAL	.55414 .01278	.63880 .01215	↑	.38700 .05312	.54560 .03938	↑	.54534 .01246	.63016 .01163	↑

The Thursday data generally reflect the Wednesday results. The major difference compared to the Wednesday data is in the through maneuvers. Whereas a significant decrease in through maneuvers was found in the Wednesday data in the After phase, a significant increase is shown in the Thursday data for autos, and no significant difference is found for nonautos and for the population as a whole.

INTERCHANGE 17 NORTH
ADVANCE (G-1) SIGN (BEFORE)
9/22/71
0930-1430

INTERCHANGE 17 NORTH
ADVANCE (G-1) SIGN (AFTER)
9/20/72
0930-1430

		LOCAL	LOCAL	FOREIGN	FOREIGN	ALL	ALL
		3713	4338	483	576	4196	4914
1.	PREP. MANUEVERS	.06518 .00794	.04172 ↓ .00595	.10973 .02787	.05382 ↓ .01843	.07031 .00774	.04314 ↓ .00568
2.	THROUGH MANUEVERS	.09615 .00948	.07884 ↓ .00802	.08903 .02540	.07292 N.S. .02123	.09533 .00889	.07814 ↓ .00750
3.	OTHER LANE CHANGES	.06545 .00795	.04149 ↓ .00593	.03727 .01689	.02778 N.S. .01342	.06220 .00731	.03989 ↓ .00547
4.	NO LANE CHANGES	.77323 .01347	.83794 ↑ .01097	.76398 .03787	.84549 ↑ .02952	.77216 .01269	.83883 ↑ .01028
1.	SPEED DIFFERENCE	.21088 .01312	.09521 ↓ .00873	.28364 .04020	.09722 ↓ .02419	.21926 .01252	.09544 ↓ .00822
2.	HEADWAY VIOLATION	.14166 .01122	.17842 ↑ .01139	.08282 .02458	.11979 ↑ .02652	.13489 .01034	.17155 ↑ .01054
3.	DBL LANE CHANGES	.00889 .00302	.01475 ↑ .00359	.01242 .00988	.01215 N.S. .00895	.00929 .00290	.01445 ↑ .00334
4.	1 + 2	.09453 .00941	.03757 ↓ .00566	.05383 .02013	.02257 .01213	.08985 .00865	.03582 ↓ .00520
5.	2 + 3	.00350 .00190	.00553 .00221	.00414 .00573	.00347 .00480	.00357 .00181	.00529 .00203
6.	1 + 3	.00512 .00230	.00277 .00156	.00207 .00405	.00347 .00480	.00477 .00208	.00285 .00149
7.	1 + 2 + 3	.00350 .00190	.00115 .00101	.00621 .00701	.00521 .00588	.00381 .00186	.00163 .00113
8.	NORMAL	.53191 .01605	.66459 ↑ .01405	.55487 .04432	.73611 ↑ .03599	.53456 .01509	.67298 ↑ .01312

The local and foreign subpopulations which were identified by manually coding vehicles by license plate as they passed through the array on Wednesday show similar results to the auto/nonauto stratification on the same day. Less lane changing activity of all types is found in the After phase, with the exception of double lane changes which are increased. The proportion of vehicles meeting the definition of normal is increased.

To obtain data on lane usage at signing locations other than gores, the total population of vehicles was divided into four subpopulations; vehicles that did not change lanes, vehicles moving toward the median, vehicles moving toward the shoulder, and vehicles moving in both directions. The proportion of vehicles not changing lanes has been shown in preceding tables and was roughly in the order of 80 percent with a significantly greater proportion in the After phase. The proportion of vehicles changing lanes in both directions within the tapeswitch array (which may be an index of confusion, or merely an index of passing other vehicles and returning to the same lane) was roughly two percent. More specifically, the proportions (top number) and their 95 percent confidence limits (bottom number) for the two paired data collection days in the Before and After phases were:

	Wednesday		Thursday	
	9/22/71	9/20/72	9/23/71	9/21/72
Vehicles Moving In	.0183	.0150	.0191	.0286
Both Directions	.0032	.0027	.0034	.0040

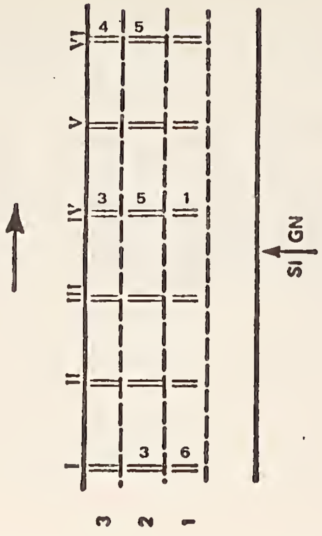
The Wednesday data are not significantly different in the Before and After phases. The Thursday data (which show a trend in the opposite direction) are significantly different at least at the .05 level. The inconsistency negates any conclusions from these data.

The tables following compare the proportion of vehicles moving toward the median and toward the shoulder in the Before and After phases.

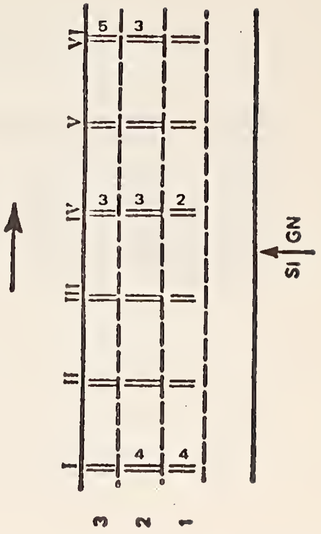
INTERCHANGE 17 NORTH
ADVANCE (G-1) SIGN (AFTER)
9/20/72
0930-1430

7813		1	2	3	4	5	6
	1 N	.0330 .0040	.0255 .0035	.0184 .0030	.0132 .0025	.0051 .0016	0.0000 0.0000
	1 HV	.0037 .0013	.0026 .0011	.0013 .0008	.0012 .0008	.0004 .0004	0.0000 0.0000
	1 LS	.0033 .0013	.0036 .0013	.0023 .0011	.0015 .0009	.0006 .0006	0.0000 0.0000
	1 HV+LS	.0006 .0006	.0001 .0003	.0001 .0003	.0001 .0003	.0003 .0004	0.0000 0.0000
VEHICLES	2 N	.0294 .0037	.0252 .0035	.0247 .0034	.0229 .0033	.0257 .0035	.0247 .0034
MOVING	2 HV	.0082 .0020	.0078 .0020	.0072 .0019	.0070 .0019	.0027 .0011	.0036 .0013
TOWARD	2 LS	.0036 .0013	.0029 .0012	.0032 .0013	.0033 .0013	.0023 .0011	.0027 .0011
MEDIAN	2 HV+LS	.0006 .0006	.0008 .0006	.0008 .0006	.0009 .0007	0.0000 0.0000	.0003 .0004
	3 N	0.0000 0.0000	.0111 .0023	.0189 .0030	.0259 .0035	.0360 .0041	.0415 .0044
	3 HV	0.0000 0.0000	.0019 .0010	.0033 .0013	.0047 .0015	.0055 .0016	.0058 .0017
	3 LS	0.0000 0.0000	.0010 .0007	.0015 .0009	.0012 .0008	.0031 .0012	.0038 .0014
	3 HV+LS	0.0000 0.0000	0.0000 0.0000	.0008 .0006	.0006 .0006	.0009 .0007	.0003 .0004

Before
%



After
%



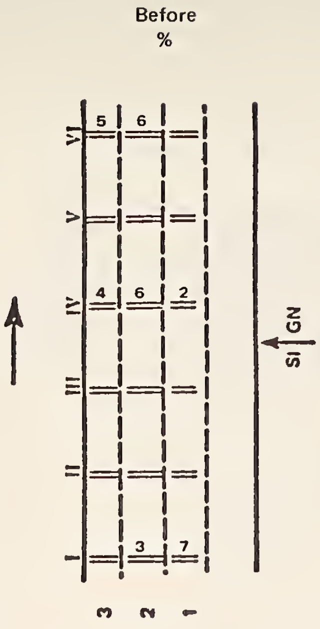
TOTALS LANE 1	.0407 .0044	.0317 .0039	.0221 .0033	.0160 .0028	.0064 .0018	0.0000 0.0000
TOTALS LANE 2	.0419 .0044	.0367 .0042	.0358 .0041	.0342 .0040	.0307 .0038	.0312 .0039
TOTALS LANE 3	0.0000 0.0000	.0141 .0026	.0246 .0034	.0324 .0039	.0454 .0046	.0513 .0049

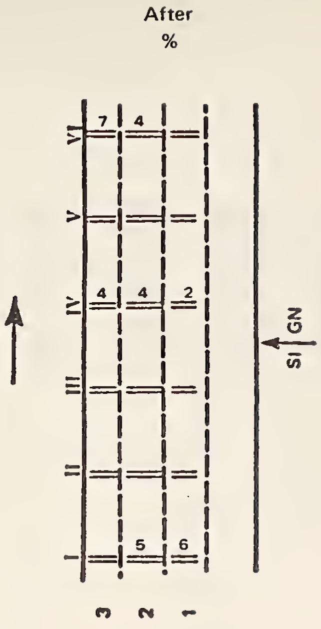
In the Before and After phases, the proportion of traffic moving towards the median was roughly similar on the Wednesday data collection period (8 to 9%). However, a significantly higher proportion of such vehicles began their movement in Lane 1 in the Before phase. (Before data are presented on the following page.) In the After phase, equal numbers of leftward moving vehicles (4%) were found in Lanes 1 and 2. At Trap 6, a significantly higher proportion of leftward moving vehicles in the After phase ended up in the median-most lane. In other words, leftward moving vehicles in the After phase are perhaps completing leftward movements initiated earlier, perhaps with higher confidence than in the Before phase. This kind of movement could account for the more even distribution seen at the gore in the two exiting traffic lanes.

```
                    INTERCHANGE 17 NORTH
                    ADVANCE (G-1) SIGN (BEFORE)
                    9/22/71
                    0930-1430

6572                     1       2       3       4       5       6

          1 N         .0368   .0288   .0173   .0078   .0032  0.0000
                      .0046   .0040   .0032   .0021   .0014  0.0000

          1 HV        .0029   .0026   .0024   .0020   .0009  0.0000
                      .0013   .0012   .0012   .0011   .0007  0.0000

          1 LS        .0167   .0128   .0088   .0038   .0017  0.0000
                      .0031   .0027   .0023   .0015   .0010  0.0000

          1 HV+LS     .0043   .0033   .0015   .0005  0.0000  0.0000
                      .0016   .0014   .0009   .0005  0.0000  0.0000

VEHICLES  2 N         .0216   .0236   .0286   .0310   .0330   .0367
                      .0035   .0037   .0040   .0042   .0043   .0045

 MOVING   2 HV        .0038   .0037   .0043   .0062   .0055   .0038
                      .0015   .0015   .0016   .0019   .0018   .0015

 TOWARD   2 LS        .0065   .0062   .0081   .0099   .0111   .0113
                      .0019   .0019   .0022   .0024   .0025   .0026

 MEDIAN   2 HV+LS     .0018   .0012   .0014   .0023   .0024   .0014
                      .0010   .0008   .0009   .0012   .0012   .0009

          3 N        0.0000   .0065   .0117   .0198   .0260   .0297    TOTALS    .0607   .0475   .0301   .0140   .0058  0.0000
                     0.0000   .0019   .0026   .0034   .0038   .0041    LANE 1    .0058   .0051   .0041   .0028   .0018  0.0000

          3 HV       0.0000   .0012   .0029   .0032   .0030   .0038    TOTALS    .0338   .0347   .0423   .0495   .0520   .0531
                     0.0000   .0008   .0013   .0014   .0013   .0015    LANE 2    .0044   .0044   .0049   .0052   .0054   .0054

          3 LS       0.0000   .0038   .0061   .0061   .0058   .0065    TOTALS   0.0000   .0123   .0221   .0310   .0367   .0414
                     0.0000   .0015   .0019   .0019   .0018   .0019    LANE 3   0.0000   .0027   .0036   .0042   .0045   .0048

          3 HV+LS    0.0000   .0008   .0014   .0020   .0018   .0014
                     0.0000   .0007   .0009   .0011   .0010   .0009
```

INTERCHANGE 17 NORTH
ADVANCE (G-1) SIGN (AFTER)
9/21/72
0930-1430

6619		1	2	3	4	5	6
	1 N	.0428 .0049	.0337 .0043	.0242 .0037	.0168 .0031	.0044 .0016	0.0000 0.0000
	1 HV	.0041 .0015	.0023 .0011	.0017 .0010	.0015 .0009	.0003 .0004	0.0000 0.0000
	1 LS	.0092 .0023	.0068 .0020	.0053 .0017	.0038 .0015	.0027 .0013	0.0000 0.0000
	1 HV+LS	.0014 .0009	.0014 .0009	.0009 .0007	.0003 .0004	.0002 .0003	0.0000 0.0000
VEHICLES	2 N	.0396 .0047	.0385 .0046	.0340 .0044	.0335 .0043	.0325 .0043	.0298 .0041
MOVING	2 HV	.0069 .0020	.0051 .0017	.0048 .0017	.0057 .0018	.0023 .0011	.0029 .0013
TOWARD	2 LS	.0038 .0015	.0036 .0014	.0039 .0015	.0041 .0015	.0039 .0015	.0047 .0016
MEDIAN	2 HV+LS	.0008 .0007	.0002 .0003	.0006 .0006	.0009 .0007	.0003 .0004	.0003 .0004
	3 N	0.0000 0.0000	.0131 .0027	.0263 .0039	.0346 .0044	.0514 .0053	.0570 .0056
	3 HV	0.0000 0.0000	.0014 .0009	.0032 .0014	.0032 .0014	.0059 .0018	.0073 .0020
	3 LS	0.0000 0.0000	.0023 .0011	.0035 .0014	.0035 .0014	.0045 .0016	.0059 .0018
	3 HV+LS	0.0000 0.0000	.0002 .0003	.0002 .0003	.0006 .0006	.0002 .0003	.0008 .0007





TOTALS LANE 1	.0574 .0056	.0441 .0049	.0320 .0042	.0224 .0036	.0076 .0021	0.0000 0.0000
TOTALS LANE 2	.0511 .0053	.0474 .0051	.0434 .0049	.0443 .0050	.0390 .0047	.0376 .0046
TOTALS LANE 3	0.0000 0.0000	.0169 .0031	.0331 .0043	.0418 .0048	.0619 .0058	.0709 .0062

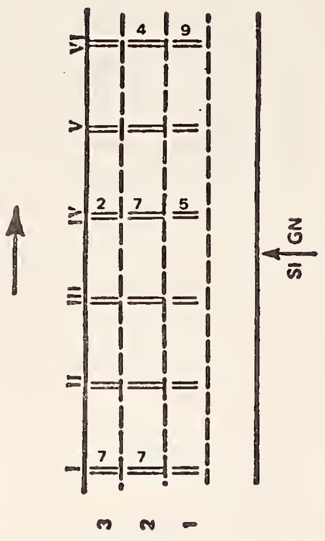
The data collected on Thursday for vehicles moving towards the median confirm the results found on Wednesday. Leftward moving vehicles enter the array more evenly distributed in Lanes 1 and 2 and a significantly larger proportion exit the array in Lane 3, the median-most lane.

```
                          INTERCHANGE 17 NORTH
                          ADVANCE (G-1) SIGN (BEFORE)
                          9/23/71
                          0930-1430

  6132                         1       2       3       4       5       6

              1 N          .0445   .0341   .0204   .0106   .0034  0.0000
                           .0052   .0045   .0035   .0026   .0015  0.0000

              1 HV         .0046   .0038   .0021   .0011   .0003  0.0000
                           .0017   .0015   .0012   .0008   .0005  0.0000

              1 LS         .0201   .0166   .0116   .0051   .0015  0.0000
                           .0035   .0032   .0027   .0018   .0010  0.0000

              1 HV+LS      .0046   .0034   .0016  0.0000  0.0000  0.0000
                           .0017   .0015   .0010  0.0000  0.0000  0.0000

 VEHICLES     2 N          .0210   .0235   .0326   .0365   .0429   .0429
                           .0036   .0038   .0044   .0047   .0051   .0051

  MOVING      2 HV         .0041   .0033   .0051   .0044   .0059   .0051
                           .0016   .0014   .0018   .0017   .0019   .0018

  TOWARD      2 LS         .0080   .0068   .0091   .0106   .0114   .0121
                           .0022   .0021   .0024   .0026   .0027   .0027

  MEDIAN      2 HV+LS      .0013   .0011   .0008   .0036   .0034   .0021
                           .0009   .0008   .0007   .0015   .0015   .0012

              3 N         0.0000   .0099   .0140   .0251   .0285   .0336     TOTALS     .0737   .0579   .0357   .0160   .0052  0.0000
                          0.0000   .0025   .0029   .0039   .0042   .0045     LANE 1     .0065   .0058   .0046   .0032   .0018  0.0000

              3 HV        0.0000   .0011   .0018   .0038   .0038   .0044     TOTALS     .0344   .0347   .0476   .0551   .0636   .0621
                          0.0000   .0008   .0011   .0015   .0015   .0017     LANE 2     .0046   .0046   .0053   .0057   .0061   .0060

              3 LS        0.0000   .0039   .0075   .0065   .0057   .0059     TOTALS    0.0000   .0155   .0248   .0362   .0393   .0460
                          0.0000   .0016   .0022   .0020   .0019   .0019     LANE 3    0.0000   .0031   .0039   .0047   .0049   .0052

              3 HV+LS     0.0000   .0005   .0015   .0008   .0013   .0021
                          0.0000   .0006   .0010   .0007   .0009   .0012
```

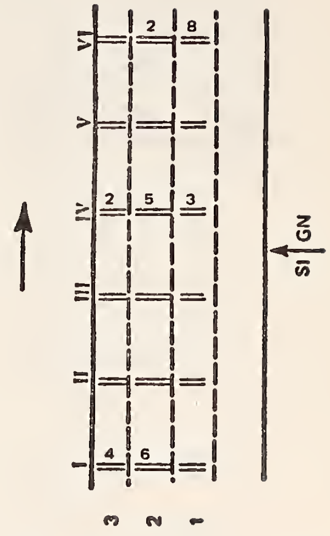
INTERCHANGE 17 NORTH
ADVANCE (G-1) SIGN (AFTER)
9/20/72
0930-1430

7813		1	2	3	4	5	6
	1 N	0.0000 0.0000	.0042 .0014	.0155 .0027	.0273 .0036	.0454 .0046	.0607 .0053
	1 HV	0.0000 0.0000	.0014 .0008	.0042 .0014	.0047 .0015	.0082 .0020	.0124 .0025
	1 LS	0.0000 0.0000	0.0000 0.0000	.0006 .0006	.0008 .0006	.0033 .0013	.0029 .0012
	1 HV+LS	0.0000 0.0000	0.0000 0.0000	.0003 .0004	.0004 .0004	.0008 .0006	.0020 .0010
VEHICLES	2 N	.0526 .0050	.0517 .0049	.0451 .0046	.0388 .0043	.0268 .0036	.0207 .0032
MOVING	2 HV	.0086 .0020	.0072 .0019	.0059 .0016	.0055 .0017	.0027 .0011	.0023 .0011
TOWARD	2 LS	.0017 .0009	.0028 .0010	.0023 .0011	.0023 .0011	.0013 .0008	.0014 .0008
SHOULDER	2 HV+LS	.0006 .0006	.0006 .0006	.0003 .0004	.0005 .0005	0.0000 0.0000	0.0000 0.0000
	3 N	.0297 .0038	.0289 .0037	.0238 .0034	.0182 .0030	.0114 .0024	0.0000 0.0000
	3 HV	.0059 .0017	.0044 .0015	.0047 .0015	.0032 .0013	.0022 .0010	0.0000 0.0000
	3 LS	.0033 .0013	.0019 .0010	.0008 .0006	.0006 .0006	.0005 .0005	0.0000 0.0000
	3 HV+LS	.0001 .0003	.0001 .0003	0.0000 0.0000	.0001 .0003	0.0000 0.0000	0.0000 0.0000

Before
%



After
%



TOTALS LANE 1	0.0000 0.0000	.0056 .0017	.0206 .0032	.0331 .0040	.0577 .0052	.0781 .0059
TOTALS LANE 2	.0635 .0054	.0616 .0053	.0526 .0050	.0472 .0047	.0307 .0038	.0244 .0034
TOTALS LANE 3	.0390 .0043	.0353 .0041	.0293 .0037	.0221 .0033	.0141 .0026	0.0000 0.0000

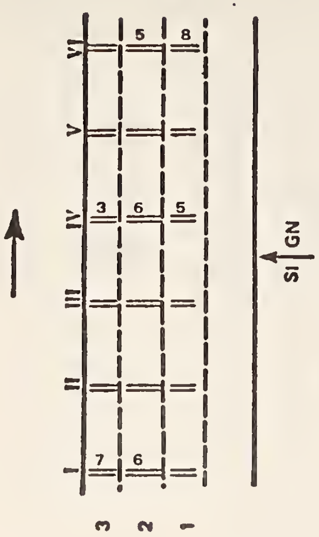
Results for vehicles moving towards the shoulder present the same picture as found for vehicles moving towards the median but in reverse. Of rightward moving vehicles, proportionately more entered the array in Lane 2 and exited the array in Lane 1. These data suggest that of vehicles moving towards the right, more may be completing a maneuver begun upstream from the tapeswitch array.

```
                  INTERCHANGE 17 NORTH
                  ADVANCE (G-1) SIGN (BEFORE)
                  9/22/71
                  0930-1430

6572                        1       2       3       4       5       6

           1 N         0.0000   .0065   .0228   .0345   .0561   .0671
                       0.0000   .0019   .0036   .0044   .0056   .0060

           1 HV        0.0000   .0023   .0044   .0050   .0099   .0123
                       0.0000   .0012   .0016   .0017   .0024   .0027

           1 LS        0.0000   .0012   .0033   .0044   .0062   .0097
                       0.0000   .0008   .0014   .0016   .0019   .0024

           1 HV+LS     0.0000  0.0000   .0006   .0030   .0030   .0030
                       0.0000  0.0000   .0006   .0013   .0013   .0013

VEHICLES   2 N          .0501   .0539   .0499   .0505   .0380   .0318
                        .0053   .0055   .0053   .0053   .0046   .0042

 MOVING    2 HV         .0070   .0050   .0046   .0073   .0062   .0049
                        .0020   .0017   .0016   .0021   .0019   .0017

 TOWARD    2 LS         .0072   .0114   .0111   .0075   .0059   .0047
                        .0020   .0026   .0025   .0021   .0019   .0017

SHOULDER   2 HV+LS      .0012   .0018   .0014   .0015   .0011   .0011
                        .0008   .0010   .0009   .0009   .0008   .0008

           3 N          .0461   .0391   .0283   .0163   .0065  0.0000    TOTALS   0.0000   .0100   .0312   .0470   .0753   .0922
                        .0051   .0047   .0040   .0031   .0019  0.0000    LANE 1   0.0000   .0024   .0042   .0051   .0064   .0070

           3 HV         .0053   .0033   .0029   .0017   .0009  0.0000    TOTALS    .0654   .0721   .0670   .0668   .0513   .0425
                        .0018   .0014   .0013   .0010   .0007  0.0000    LANE 2    .0060   .0063   .0060   .0060   .0053   .0049

           3 LS         .0143   .0082   .0040   .0026   .0006  0.0000    TOTALS    .0692   .0525   .0365   .0208   .0081  0.0000
                        .0029   .0022   .0015   .0012   .0006  0.0000    LANE 3    .0061   .0054   .0045   .0035   .0022  0.0000

           3 HV+LS      .0035   .0018   .0014   .0003  0.0000  0.0000
                        .0014   .0010   .0009   .0004  0.0000  0.0000
```

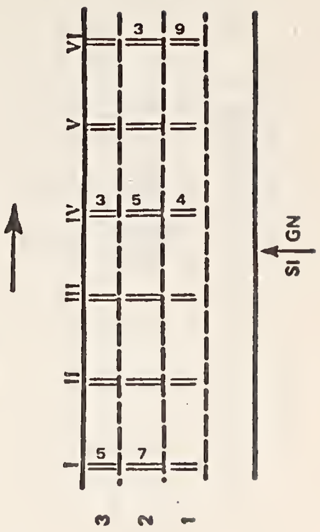
INTERCHANGE 17 NORTH
ADVANCE (G-1) SIGN (AFTER)
9/21/72
0930-1430

6619		1	2	3	4	5	6
	1 N	0.0000 0.0000	.0062 .0019	.0190 .0033	.0343 .0044	.0508 .0053	.0754 .0064
	1 HV	0.0000 0.0000	.0006 .0006	.0027 .0013	.0038 .0015	.0042 .0016	.0083 .0022
	1 LS	0.0000 0.0000	.0005 .0006	.0018 .0010	.0021 .0011	.0051 .0017	.0056 .0018
	1 HV+LS	0.0000 0.0000	.0002 .0003	.0003 .0004	.0005 .0005	.0011 .0008	.0030 .0013
VEHICLES	2 N	.0612 .0058	.0582 .0056	.0485 .0052	.0411 .0048	.0302 .0041	.0215 .0035
MOVING	2 HV	.0062 .0019	.0054 .0018	.0026 .0012	.0042 .0016	.0015 .0009	.0029 .0013
TOWARD	2 LS	.0020 .0011	.0027 .0013	.0042 .0016	.0044 .0016	.0033 .0014	.0017 .0010
SHOULDER	2 HV+LS	.0005 .0005	.0009 .0007	.0008 .0007	.0006 .0006	.0002 .0003	0.0000 0.0000
	3 N	.0366 .0045	.0346 .0044	.0298 .0041	.0207 .0034	.0165 .0031	0.0000 0.0000
	3 HV	.0056 .0018	.0047 .0016	.0045 .0016	.0036 .0014	.0026 .0012	0.0000 0.0000
	3 LS	.0051 .0017	.0036 .0014	.0032 .0014	.0027 .0013	.0024 .0012	0.0000 0.0000
	3 HV+LS	.0012 .0008	.0006 .0006	.0008 .0007	.0003 .0004	.0005 .0005	0.0000 0.0000

Before
%



After
%



TOTALS LANE 1	0.0000 0.0000	.0076 .0021	.0239 .0037	.0406 .0048	.0612 .0058	.0923 .0070
TOTALS LANE 2	.0698 .0061	.0672 .0060	.0562 .0055	.0503 .0053	.0352 .0044	.0260 .0038
TOTALS LANE 3	.0485 .0052	.0435 .0049	.0382 .0046	.0273 .0039	.0219 .0035	0.0000 0.0000

The data collected on Thursday for vehicles moving towards the shoulder confirms the Wednesday findings. Of rightward moving vehicles, a significantly lower proportion begin their movement from Lane 3 in the After phase.

```
                 INTERCHANGE 17 NORTH
                 ADVANCE (G-1) SIGN (BEFORE)
                 9/23/71
                 0930-1430

6132                    1        2        3        4        5        6

           1 N       0.0000    .0101    .0225    .0331    .0528    .0634
                     0.0000    .0025    .0037    .0045    .0056    .0061

           1 HV      0.0000    .0020    .0033    .0059    .0062    .0085
                     0.0000    .0011    .0014    .0019    .0020    .0023

           1 LS      0.0000    .0008    .0021    .0059    .0083    .0093
                     0.0000    .0007    .0012    .0019    .0023    .0024

           1 HV+LS   0.0000    .0007    .0015    .0018    .0023    .0033
                     0.0000    .0006    .0010    .0011    .0012    .0014

VEHICLES   2 N        .0439    .0466    .0484    .0437    .0346    .0339
                      .0051    .0053    .0054    .0051    .0046    .0045

 MOVING    2 HV       .0057    .0034    .0042    .0060    .0075    .0068
                      .0019    .0015    .0016    .0019    .0022    .0021

 TOWARD    2 LS       .0088    .0086    .0090    .0078    .0068    .0054
                      .0023    .0023    .0024    .0022    .0021    .0018

SHOULDER   2 HV+LS    .0016    .0011    .0011    .0021    .0013    .0007
                      .0010    .0008    .0008    .0012    .0009    .0006

           3 N        .0488    .0424    .0287    .0184    .0090   0.0000      TOTALS    0.0000    .0135    .0294    .0466    .0696    .0845
                      .0054    .0050    .0042    .0034    .0024   0.0000      LANE 1    0.0000    .0029    .0042    .0053    .0064    .0070

           3 HV       .0085    .0082    .0044    .0033    .0018   0.0000      TOTALS     .0600    .0598    .0628    .0597    .0502    .0468
                      .0023    .0023    .0017    .0014    .0011   0.0000      LANE 2     .0059    .0059    .0061    .0059    .0055    .0053

           3 LS       .0114    .0057    .0041    .0023    .0003   0.0000      TOTALS     .0713    .0579    .0391    .0250    .0114   0.0000
                      .0027    .0019    .0016    .0012    .0005   0.0000      LANE 3     .0064    .0358    .0049    .0039    .0027   0.0000

           3 HV+LS    .0026    .0016    .0020    .0010    .0003   0.0000
                      .0013    .0010    .0011    .0008    .0005   0.0000
```

In summary, a significant reduction in preparatory maneuvers was found at the exit direction location. Through maneuvers were more variable. Other lane changes were significantly reduced and the proportion of vehicles not changing lanes was consistently increased in the After phase. Lane placement data for vehicles moving toward the median and toward the shoulder is compatible with the hypothesis that such movements were continuations of maneuvers begun at a more upstream location. The shift in vehicles moving toward the median is compatible with the more even distribution of traffic across the two exiting lanes at the gore. It is concluded that the data indicate that the reduction in weaving activity at the gore is accounted for by movements initiated at a more upstream location, i.e., at the advance sign, or some intermediate location between the advance and exit direction signs.

Advance (G-2) Sign. Tapeswitch instrumentation paralleled that at the exit direction location. The shoulder-most lane was not instrumented. The switches were deployed symmetrically about the sign, extending 750 feet in each direction upstream and downstream from it.

The percent of traffic in each of the three instrumented lanes was:

		Before		After	
		9/20/71	9/21/71	9/18/72	9/19/72
Trap 1	Lane 1	35.7	36.3	34.6	35.5
	Lane 2	41.1	42.5	40.4	42.7
	Lane 3	23.2	21.2	25.0	21.9
Trap 4	Lane 1	33.3	33.3	32.8	34.3
	Lane 2	43.8	42.9	42.9	44.0
	Lane 3	22.8	23.8	24.3	21.7
Trap 6	Lane 1	34.7	35.7	35.0	36.5
	Lane 2	42.3	40.0	40.7	42.2
	Lane 3	23.0	24.3	24.4	21.4

Compared to the exit direction location, the volume distributions show that the shoulder-most lane (Lane 3) carried a somewhat lower percentage of vehicles.

The mean speed in all lanes was somewhat higher than that found at the exit direction location. At the advance sign, the ranges in mean speed by lane measured across all four data collection days (at Trap 6) were:

Lane	Range In Mean Speed
1	60-62
2	61-62
3	67-68

As at the exit direction location, the highest mean speed was found in instrumented Lane 3, the lane closest to the median, as might be expected.

The tables on the following pages show the proportions of vehicles performing preparatory, through and other lane changing maneuvers as well as the proportions of vehicles meeting the previously defined criteria for speed differences, headway violations, double lane changes and various combinations of these. The last tables in the set show the lane usage by vehicles studied in the Before and After phases.

INTERCHANGE 17 NORTH
ADVANCE (G-2) SIGN (BEFORE)
9/20/71
0930-1430

INTERCHANGE 17 NORTH
ADVANCE (G-2) SIGN (AFTER)
9/18/72
0930-1430

		AUTOS	AUTOS		NONAUTOS	NONAUTOS		ALL	ALL	
		7032	7952		525	639		7557	8591	
1.	PREP. MANUEVERS	.07565 .00618	.08463 .00612	↑	.10857 .02661	.12207 .02538	N.S.	.07794 .00604	.08742 .00597	↑
2.	THROUGH MANUEVERS	.06769 .00587	.08903 .00626	↑	.02857 .01425	.04069 .01532	N.S.	.06497 .00556	.08544 .00591	↑
3.	OTHER LANE CHANGES	.03143 .00408	.02804 .00363	N.S.	.00381 .00527	.01408 .00914	N.S.	.02951 .00382	.02701 .00343	N.S.
4.	NO LANE CHANGES	.82523 .00888	.79829 .00882	↓	.85905 .02977	.82316 .02958	N.S.	.82758 .00852	.80014 .00846	↓
1.	SPEED DIFFERENCE	.19127 .00919	.19542 .00872	N.S.	.37714 .04146	.37715 .03758	N.S.	.20418 .00909	.20894 .00860	N.S.
2.	HEADWAY VIOLATION	.12187 .00765	.13858 .00759	↑	.10095 .02577	.12363 .02552	N.S.	.12042 .00734	.13747 .00728	↑
3.	DBL LANE CHANGES	.00469 .00160	.00629 .00174	N.S.	.00190 .00373	.00156 .00306	N.S.	.00450 .00151	.00594 .00162	N.S.
4.	1 + 2	.07338 .00609	.09545 .00646	↑	.08381 .02370	.10798 .02406	N.S.	.07410 .00591	.09638 .00624	↑
5.	2 + 3	.00427 .00152	.00390 .00137	N.S.	0.00000 0.00000	.00156 .00306		.00397 .00142	.00372 .00129	N.S.
6.	1 + 3	.00242 .00115	.00314 .00123	N.S.	.00190 .00373	0.00000 0.00000		.00238 .00110	.00291 .00114	N.S.
7.	1 + 2 + 3	.00341 .00136	.00415 .00141	N.S.	.00190 .00373	0.00000 0.00000		.00331 .00129	.00384 .00131	N.S.
8.	NORMAL	.59869 .01146	.55307 .01093	↓	.43238 .04238	.38811 .03778	N.S.	.58714 .01110	.54080 .01054	↓

For the Monday paired data, preparatory and through maneuvers are significantly increased, and the proportion of vehicles performing no lane changes is significantly reduced for the population as a whole and for the auto subpopulation. The opposite results were found at the exit direction location. Few other significant differences were found. However, a small but significant increase in headway violations is found for autos and for the population as a whole and the proportion of vehicles classified as normal is significantly reduced (because of the increase in headway violations) in the same groups in the After phase.

INTERCHANGE 17 NORTH
ADVANCE (G-2) SIGN (BEFORE)
9/21/71
0930-1430

INTERCHANGE 17 NORTH
ADVANCE (G-2) SIGN (AFTER)
9/19/72
0930-1430

		AUTOS	AUTOS		NONAUTOS	NONAUTOS		ALL	ALL	
		5293	7477		391	632		5684	8109	
1.	PREP. MANUEVERS	.08086 .00734	.08667 .00638	N.S.	.13811 .03420	.12184 .02550	N.S.	.08480 .00724	.08941 .00621	N.S.
2.	THROUGH MANUEVERS	.07463 .00708	.09723 .00672	↑	.02302 .01486	.03481 .01429	N.S.	.07108 .00668	.09237 .00630	↑
3.	OTHER LANE CHANGES	.04837 .00578	.03089 .00392	↓	.02813 .01639	.01424 .00924	N.S.	.04697 .00550	.02960 .00369	↓
4.	NO LANE CHANGES	.79615 .01095	.78521 .00931	N.S.	.81074 .03883	.82911 .02935	N.S.	.79715 .01045	.78863 .00889	N.S.
1.	SPEED DIFFERENCE	.15247 .00968	.18925 .00888	↑	.36317 .04767	.38608 .03796	N.S.	.16696 .00970	.20459 .00878	↑
2.	HEADWAY VIOLATION	.14680 .00953	.15006 .00810	N.S.	.07673 .02638	.10285 .02368	N.S.	.14198 .00907	.14638 .00769	N.S.
3.	DBL LANE CHANGES	.00794 .00239	.00776 .00199	N.S.	.00767 .00865	0.00000 0.00000		.00792 .00230	.00715 .00183	N.S.
4.	1 + 2	.06971 .00686	.09576 .00667	↑	.09974 .02970	.11867 .02521	N.S.	.07178 .00671	.09755 .00646	↑
5.	2 + 3	.00491 .00188	.00535 .00165	N.S.	.00256 .00501	0.00000 0.00000		.00475 .00179	.00493 .00152	N.S.
6.	1 + 3	.00907 .00255	.00495 .00159	↓	.00256 .00501	.00158 .00310	N.S.	.00862 .00240	.00469 .00149	↓
7.	1 + 2 + 3	.00567 .00202	.00602 .00175	N.S.	.00256 .00501	.00158 .00310	N.S.	.00545 .00191	.00567 .00163	N.S.
8.	NORMAL	.60344 .01318	.54086 .01130	↓	.44501 .04926	.38924 .03801	↓	.59254 .01277	.52904 .01086	↓

For the Tuesday paired data, the only consistent change in the maneuver data compared to the Monday data is the increase in through maneuvers. As in the Monday data, the proportion of vehicles classified as normal is reduced in the After phase.

INTERCHANGE 17 NORTH
ADVANCE (G-2) SIGN (BEFORE)
9/21/71
0930-1430

INTERCHANGE 17 NORTH
ADVANCE (G-2) SIGN (AFTER)
9/19/72
0930-1430

		LOCAL	LOCAL		FOREIGN	FOREIGN		ALL	ALL	
		3120	4011		353	520		3473	4531	
1.	PREP. MANUEVERS	.08333 .00970	.09100 .00890	N.S.	.04533 .02170	.08077 .02342	↑	.07947 .00900	.08983 .00833	N.S.
2.	THROUGH MANUEVERS	.06635 .00873	.08477 .00862	↑	.10198 .03157	.11154 .02706	N.S.	.06997 .00848	.08784 .00824	↑
3.	OTHER LANE CHANGES	.04712 .00743	.02942 .00523	↓	.05382 .02354	.03654 .01613	N.S.	.04780 .00710	.03024 .00499	↓
4.	NO LANE CHANGES	.80321 .01395	.79481 .01250	N.S.	.79887 .04182	.77115 .03611	N.S.	.80276 .01323	.79210 .01182	N.S.
1.	SPEED DIFFERENCE	.17308 .01327	.19097 .01216	N.S.	.15297 .03755	.20577 .03475	↑	.17103 .01252	.19267 .01148	↑
2.	HEADWAY VIOLATION	.13910 .01214	.15233 .01112	N.S.	.11615 .03342	.12500 .02843	N.S.	.13677 .01143	.14919 .01037	N.S.
3.	DBL LANE CHANGES	.00801 .00313	.00723 .00262	N.S.	.00850 .00958	.00769 .00751	N.S.	.00806 .00297	.00728 .00248	N.S.
4.	1 + 2	.07372 .00917	.09624 .00913	↑	.04249 .02104	.06923 .02182	N.S.	.07054 .00852	.09314 .00846	↑
5.	2 + 3	.00577 .00266	.00374 .00189	N.S.	.00850 .00958	.00385 .00532	N.S.	.00605 .00258	.00375 .00178	N.S.
6.	1 + 3	.00833 .00319	.00573 .00234	N.S.	.01700 .01348	.00385 .00532	N.S.	.00921 .00318	.00552 .00216	N.S.
7.	1 + 2 + 3	.00673 .00287	.00399 .00195	N.S.	.00567 .00783	0.00000 0.00000		.00662 .00270	.00353 .00173	N.S.
8.	NORMAL	.58526 .01729	.53977 .01542	↓	.64873 .04980	.58462 .04236	↓	.59171 .01635	.54491 .01450	↓

Changes in the local/foreign subpopulations in the After phase show a significant increase in preparatory maneuvers for foreign (i.e., nonlocal) vehicles and in through maneuvers for local vehicles.

The three tables which have been presented indicate that through maneuvers are significantly increased at the advance locations for populations of significant size (the population as a whole and the auto and local vehicle subpopulations). Preparatory maneuver results are mixed showing an increase or no significant difference depending upon the population and the day on which data were collected.

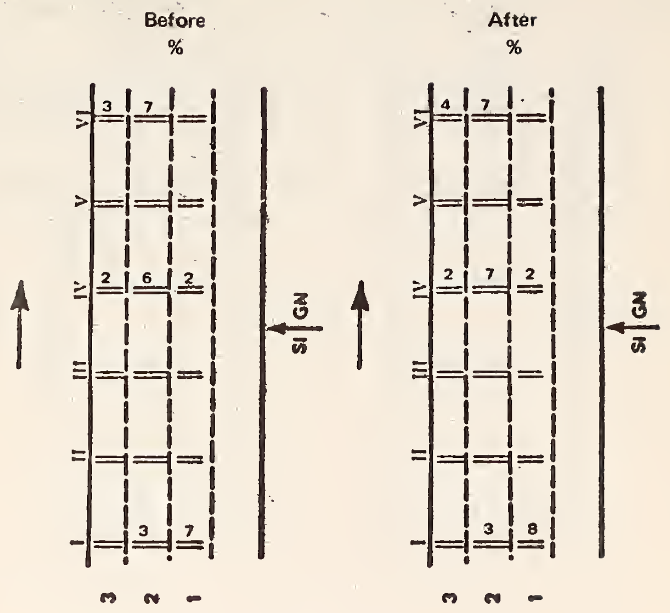
Attention is next turned to the lane placement data at this signing location. As at the exit direction sign location, the proportion of vehicles performing no lane changes was roughly 80 percent. The proportion of vehicles moving in both directions was about one percent (compared to two percent at the exit direction location). More specifically, the proportions (top number) and their 95 percent confidence limits (bottom number) for the two paired data collection days in the Before and After phases were:

	Monday		Tuesday	
	9/20/71	9/18/72	9/21/71	9/19/72
Vehicles Moving In Both Directions	.0053 .0016	.0078 .0019	.0127 .0029	.0112 .0023

The Monday data show a significant increase in the After phase whereas the Tuesday data are not significantly different. The small size of the proportions and the inconsistency of the data negate drawing any conclusions.

The following tables compare the proportion of vehicles moving toward the median and toward the shoulder in the Before and After phases.

```
                           INTERCHANGE 17 NORTH
                           ADVANCE ( G-2) SIGN (AFTER)
                           9/18/72
                           0930-1430

8591                         1        2        3        4        5        6

             1 N           .0407    .0349    .0204    .0111    .0055   0.0000
                           .0042    .0039    .0030    .0022    .0016   0.0000

             1 HV          .0065    .0054    .0035    .0017    .0006   0.0000
                           .0017    .0015    .0012    .0009    .0005   0.0000

             1 LS          .0244    .0171    .0108    .0064    .0023   0.0000
                           .0033    .0027    .0022    .0017    .0010   0.0000

             1 HV+LS       .0098    .0056    .0014    .0006    .0006   0.0000
                           .0021    .0016    .0008    .0005    .0005   0.0000

VEHICLES     2 N           .0191    .0272    .0372    .0448    .0455    .0478
                           .0029    .0034    .0040    .0044    .0044    .0045

MOVING       2 HV          .0042    .0064    .0086    .0090    .0079    .0065
                           .0014    .0017    .0020    .0020    .0019    .0017

TOWARD       2 LS          .0022    .0056    .0120    .0132    .0152    .0149
                           .0010    .0016    .0023    .0024    .0026    .0026

MEDIAN       2 HV+LS       .0012    .0024    .0034    .0027    .0016    .0023
                           .0007    .0010    .0012    .0011    .0009    .0010

             3 N          0.0000    .0016    .0061    .0112    .0176    .0205
                          0.0000    .0009    .0016    .0022    .0028    .0030

             3 HV         0.0000    .0003    .0009    .0019    .0024    .0028
                          0.0000    .0004    .0006    .0009    .0010    .0011

             3 LS         0.0000    .0014    .0035    .0051    .0083    .0122
                          0.0000    .0008    .0012    .0015    .0019    .0023

             3 HV+LS      0.0000    .0001    .0003    .0006    .0006    .0010
                          0.0000    .0002    .0004    .0005    .0005    .0007
```



```
TOTALS      .0815    .0630    .0361    .0198    .0090   0.0000
LANE 1      .0058    .0051    .0039    .0029    .0020   0.0000

TOTALS      .0267    .0417    .0612    .0696    .0703    .0716
LANE 2      .0034    .0042    .0051    .0054    .0054    .0055

TOTALS     0.0000    .0035    .0108    .0187    .0289    .0365
LANE 3     0.0000    .0012    .0022    .0029    .0035    .0040
```

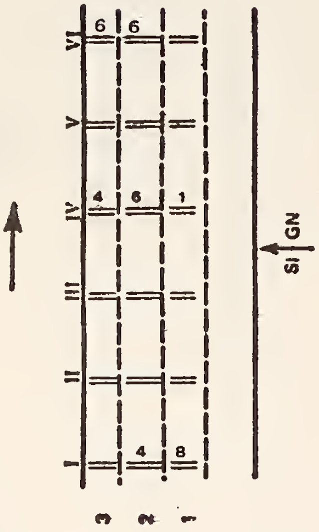
The Monday paired data for vehicles moving towards the median show no significant differences for the Before and After phases.

```
                              INTERCHANGE 17 NORTH
                              ADVANCE ( G-2) SIGN (BEFORE)
                              9/20/71
                              0930-1430


7557                               1       2       3       4       5       6

             1 N               .0384   .0329   .0212   .0112   .0036  0.0000
                               .0043   .0040   .0032   .0024   .0013  0.0000

             1 HV              .0075   .0048   .0021   .0013   .0011  0.0000
                               .0020   .0016   .0010   .0008   .0007  0.0000

             1 LS              .0212   .0155   .0111   .0062   .0019  0.0000
                               .0032   .0028   .0024   .0018   .0010  0.0000

             1 HV+LS           .0077   .0053   .0029   .0004   .0003  0.0000
                               .0020   .0016   .0012   .0004   .0004  0.0000

VEHICLES     2 N               .0192   .0240   .0327   .0401   .0418   .0422
                               .0031   .0034   .0040   .0044   .0045   .0045

 MOVING      2 HV              .0028   .0060   .0061   .0070   .0085   .0057
                               .0012   .0017   .0018   .0019   .0021   .0017

 TOWARD      2 LS              .0025   .0067   .0114   .0136   .0164   .0156
                               .0011   .0018   .0024   .0026   .0029   .0028

 MEDIAN      2 HV+LS           .0013   .0021   .0022   .0026   .0022   .0021
                               .0008   .0010   .0011   .0012   .0011   .0010

             3 N              0.0000   .0017   .0069   .0120   .0171   .0246    TOTALS     .0748   .0585   .0373   .0192   .0067  0.0000
                              0.0000   .0009   .0019   .0025   .0029   .0035    LANE 1     .0059   .0053   .0043   .0031   .0018  0.0000

             3 HV             0.0000  0.0000   .0005   .0017   .0021   .0024    TOTALS     .0258   .0388   .0524   .0634   .0689   .0656
                              0.0000  0.0000   .0005   .0009   .0010   .0011    LANE 2     .0036   .0044   .0050   .0055   .0057   .0056

             3 LS             0.0000   .0015   .0028   .0037   .0048   .0065    TOTALS    0.0000   .0033   .0109   .0180   .0249   .0349
                              0.0000   .0009   .0012   .0014   .0016   .0018    LANE 3    0.0000   .0013   .0023   .0030   .0035   .0041

             3 HV+LS          0.0000   .0001   .0007   .0005   .0009   .0015
                              0.0000   .0003   .0006   .0005   .0007   .0009
```

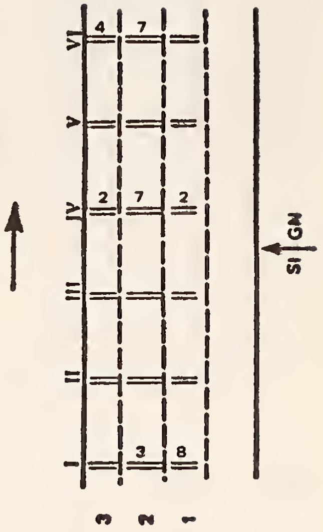
INTERCHANGE 17 NORTH
ACVANCE (G-2) SIGN (AFTER)
9/19/72
0930-1430

8109		1	2	3	4	5	6
	1 N	.0459 .0046	.0375 .0041	.0196 .0030	.0090 .0021	.0032 .0012	0.0000 0.0000
	1 HV	.0073 .0018	.0074 .0019	.0026 .0011	.0020 .0010	.0007 .0086	0.0000 0.0000
	1 LS	.0215 .0032	.0171 .0028	.0080 .0019	.0055 .0016	.0018 .0009	0.0000 0.0000
	1 HV+LS	.0078 .0019	.0025 .0011	.0006 .0005	.0006 .0005	.0004 .0004	0.0000 0.0000
VEHICLES	2 N	.0195 .0030	.0252 .0034	.0417 .0044	.0455 .0045	.0465 .0046	.0432 .0044
MOVING	2 HV	.0057 .0016	.0074 .0019	.0089 .0020	.0112 .0023	.0091 .0021	.0072 .0018
TOWARD	2 LS	.0036 .0013	.0090 .0021	.0148 .0026	.0152 .0027	.0163 .0028	.0174 .0028
MEDIAN	2 HV+LS	.0014 .0008	.0021 .0010	.0042 .0014	.0030 .0012	.0032 .0012	.0031 .0012
	3 N	0.0000 0.0000	.0021 .0010	.0068 .0018	.0121 .0024	.0189 .0030	.0257 .0034
	3 HV	0.0000 0.0000	.0005 .0005	.0009 .0006	.0018 .0009	.0031 .0012	.0051 .0015
	3 LS	0.0000 0.0000	.0010 .0007	.0035 .0013	.0058 .0017	.0078 .0019	.0086 .0020
	3 HV+LS	0.0000 0.0000	.0007 .0006	.0018 .0007	.0007 .0006	.0015 .0008	.0023 .0011

Before
%



After
%

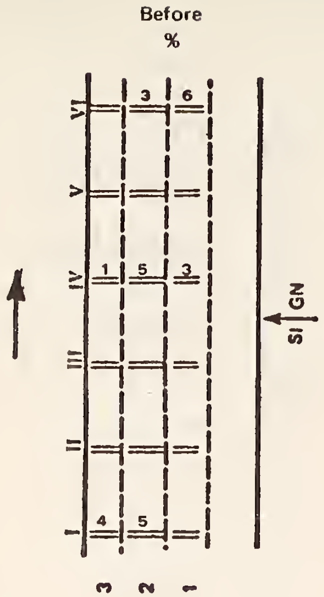


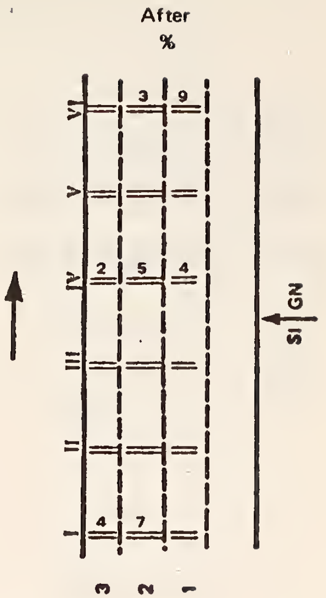
TCTALS LANE 1	.0824 .0060	.0645 .0053	.0308 .0038	.0171 .0028	.0062 .0017	0.0000 0.0000
TCTALS LANE 2	.0301 .0037	.0437 .0044	.0696 .0055	.0749 .0057	.0751 .0057	.0708 .0056
TOTALS LANE 3	0.0000 0.0000	.0043 .0014	.0121 .0024	.0205 .0031	.0312 .0038	.0417 .0044

There are a few significant differences in the Tuesday data for vehicles moving towards the median but the pattern of changes is not consistent with the trends found in the Monday data. Lane placement data for vehicles moving towards the median at the advance sign thus sheds no light on the impact of the diagrammatics on traffic behavior.

```
                          INTERCHANGE 17  NORTH
                          ADVANCE ( G-2)  SIGN (BEFORE)
                          9/21/71
                          0930-1430

5684                           1         2         3         4         5         6

            1 N             .0473     .0347     .0194     .0093     .0011    0.0000
                            .0055     .0049     .0036     .0024     .0008    0.0000

            1 HV            .0072     .0062     .0049     .0037     .0002    0.0000
                            .0022     .0020     .0018     .0007     .0003    0.0000

            1 LS            .0165     .0121     .0083     .0030     .0004    0.0000
                            .0033     .0028     .0024     .0014     .0005    0.0000

            1 HV+LS         .0060     .0037     .0018    0.0000    0.0000    0.0000
                            .0020     .0016     .0011    0.0000    0.0000    0.0000

VEHICLES    2 N             .0317     .0336     .0369     .0442     .0454     .0398
                            .0046     .0047     .0049     .0053     .0054     .0051

 MOVING     2 HV            .0060     .0081     .0072     .0077     .0083     .0069
                            .0020     .0023     .0022     .0023     .0024     .0021

 TOWARD     2 LS            .0053     .0070     .0079     .0130     .0125     .0099
                            .0019     .0022     .0023     .0026     .0029     .0026

 MEDIAN     2 HV+LS         .0012     .0011     .0014     .0025     .0018     .0023
                            .0009     .0008     .0010     .0013     .0011     .0012

            3 N            0.0000     .0128     .0269     .0362     .0399     .0471     TOTALS     .0771     .0567     .0343     .0120     .0016    0.0000
                           0.0000     .0029     .0042     .0049     .0051     .0055     LANE 1     .0069     .0060     .0047     .0028     .0010    0.0000

            3 HV           0.0000     .0007     .0030     .0039     .0044     .0055     TOTALS     .0442     .0498     .0535     .0644     .0679     .0588
                           0.0000     .0007     .0014     .0016     .0017     .0019     LANE 2     .0053     .0057     .0058     .0064     .0065     .0061

            3 LS           0.0000     .0012     .0028     .0042     .0069     .0091     TOTALS    0.0000     .0148     .0334     .0449     .0517     .0625
                           0.0000     .0009     .0014     .0017     .0021     .0025     LANE 3    0.0000     .0031     .0047     .0054     .0058     .0063

            3 HV+LS        0.0000    0.0000     .0007     .0005     .0005     .0007
                           0.0000    0.0000     .0007     .0006     .0006     .0007
```

```
INTERCHANGE 17 NORTH
ADVANCE ( G-2) SIGN (AFTER)
9/18/72
0930-1430

8591                      1        2        3        4        5        6

            1 N        0.0000    .0074    .0189    .0324    .0528    .0623
                       0.0000    .0018    .0029    .0037    .0047    .0051

            1 HV       0.0000    .0015    .0024    .0059    .0078    .0105
                       0.0000    .0009    .0010    .0016    .0019    .0022

            1 LS       0.0000    .0006    .0017    .0038    .0057    .0090
                       0.0000    .0005    .0009    .0013    .0016    .0020

            1 HV+LS    0.0000    .0003    .0006    .0017    .0033    .0036
                       0.0000    .0004    .0005    .0009    .0012    .0013

VEHICLES    2 N         .0555    .0503    .0467    .0386    .0275    .0214
                        .0048    .0046    .0045    .0041    .0035    .0031

MOVING      2 HV        .0064    .0059    .0056    .0057    .0045    .0033
                        .0017    .0016    .0016    .0016    .0014    .0012

TOWARD      2 LS        .0057    .0059    .0063    .0048    .0017    .0008
                        .0016    .0016    .0017    .0015    .0009    .0006

SHOULDER    2 HV+LS     .0012    .0015    .0022    .0013    .0007    .0005
                        .0007    .0008    .0010    .0008    .0006    .0005

            3 N         .0321    .0278    .0192    .0122    .0049   0.0000
                        .0037    .0035    .0029    .0023    .0015   0.0000

            3 HV        .0050    .0036    .0033    .0024    .0010   0.0000
                        .0015    .0013    .0012    .0010    .0007   0.0000

            3 LS        .0043    .0052    .0038    .0019    .0010   0.0000
                        .0014    .0015    .0013    .0009    .0007   0.0000

            3 HV+LS     .0010    .0010    .0006    .0005    .0002   0.0000
                        .0007    .0007    .0005    .0005    .0003   0.0000
```



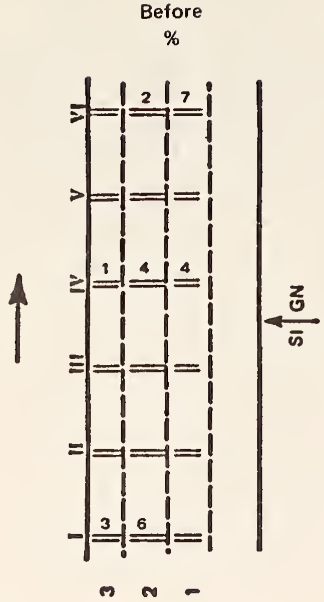


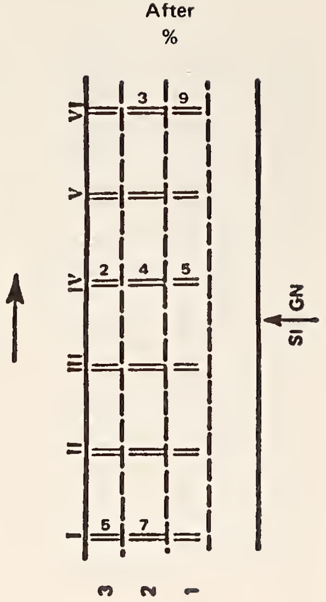
```
TOTALS    0.0000    .0099    .0236    .0439    .0696    .0853
LANE 1    0.0000    .0021    .0032    .0043    .0054    .0059

TOTALS     .0688    .0637    .0608    .0504    .0345    .0260
LANE 2     .0054    .0052    .0051    .0046    .0039    .0034

TOTALS     .0425    .0377    .0269    .0170    .0072   0.0000
LANE 3     .0043    .0040    .0034    .0027    .0018   0.0000
```

The Monday paired data for vehicles moving towards the shoulder indicates that a higher proportion of vehicles performed such maneuvers in the After phase (consistent with the increase in through maneuvers previously shown). Of vehicles shifting to the right, a significantly higher proportion exit the array in Lane 1.

```
                      INTERCHANGE 17 NORTH
                      ADVANCE ( G-2) SIGN (BEFORE)
                      9/20/71
                      0930-1430


7557                          1        2        3        4        5        6

              1 N        0.0000    .0064    .0142    .0250    .0398    .0525
                         0.0000    .0018    .0027    .0035    .0044    .0050

              1 HV       0.0000    .0004    .0021    .0034    .0045    .0056
                         0.0000    .0004    .0010    .0013    .0015    .0017

              1 LS       0.0000    .0003    .0013    .0021    .0034    .0044
                         0.0000    .0004    .0008    .0010    .0013    .0015

              1 HV+LS    0.0000    .0001   0.0000    .0007    .0008    .0021
                         0.0000    .0003   0.0000    .0006    .0006    .0010

VEHICLES      2 N         .0419    .0406    .0402    .0352    .0277    .0229
                          .0045    .0045    .0044    .0042    .0037    .0034

 MOVING       2 HV        .0064    .0053    .0049    .0061    .0045    .0024
                          .0018    .0016    .0016    .0018    .0015    .0011

 TOWARD       2 LS        .0054    .0057    .0046    .0032    .0025    .0005
                          .0017    .0017    .0015    .0013    .0011    .0005

SHOULDER      2 HV+LS     .0003    .0007    .0011    .0011    .0007    .0005
                          .0004    .0006    .0007    .0007    .0006    .0005

              3 N         .0267    .0228    .0168    .0110    .0048   0.0000     TOTALS     0.0000    .0071    .0176    .0312    .0486    .0646
                          .0036    .0034    .0029    .0023    .0016   0.0000     LANE 1     0.0000    .0019    .0030    .0039    .0048    .0055

              3 HV        .0034    .0034    .0021    .0012    .0008   0.0000     TOTALS      .0540    .0523    .0508    .0455    .0353    .0263
                          .0013    .0013    .0010    .0008    .0006   0.0000     LANE 2      .0051    .0050    .0050    .0047    .0042    .0036

              3 LS        .0054    .0046    .0033    .0017    .0011   0.0000     TOTALS      .0369    .0315    .0225    .0142    .0070   0.0000
                          .0017    .0015    .0013    .0009    .0007   0.0000     LANE 3      .0043    .0039    .0033    .0027    .0019   0.0000

              3 HV+LS     .0013    .0007    .0003    .0003    .0004   0.0000
                          .0008    .0006    .0004    .0004    .0004   0.0000
```

```
                              INTERCHANGE 17 NORTH
                              ADVANCE ( G-2) SIGN (AFTER)
                              9/19/72
                              0930-1430

8109                             1         2         3         4         5         6

              1 N             0.0000     .0083     .0200     .0414     .0580     .0687
                              0.0000     .0020     .0030     .0043     .0051     .0055

              1 HV            0.0000     .0007     .0017     .0057     .0086     .0113
                              0.0000     .0006     .0009     .0016     .0020     .0023

              1 LS            0.0000     .0007     .0031     .0044     .0072     .0095
                              0.0000     .0006     .0012     .0014     .0018     .0021

              1 HV+LS         0.0000     .0005     .0004     .0021     .0014     .0026
                              0.0000     .0005     .0004     .0010     .0008     .0011

VEHICLES      2 N              .0551     .0492     .0440     .0322     .0280     .0210
                               .0050     .0047     .0045     .0038     .0036     .0031

MOVING        2 HV             .0075     .0095     .0094     .0060     .0054     .0042
                               .0019     .0021     .0021     .0017     .0016     .0014

TOWARD        2 LS             .0088     .0083     .0070     .0041     .0027     .0015
                               .0020     .0020     .0018     .0014     .0011     .0008

SHOULDER      2 HV+LS          .0018     .0009     .0010     .0010     .0011     .0007
                               .0009     .0006     .0007     .0007     .0007     .0006

              3 N              .0337     .0302     .0233     .0160     .0044    0.0000
                               .0039     .0037     .0033     .0027     .0014    0.0000

              3 HV             .0051     .0041     .0033     .0026     .0011    0.0000
                               .0015     .0014     .0013     .0011     .0007    0.0000

              3 LS             .0064     .0062     .0054     .0035     .0014    0.0000
                               .0017     .0017     .0016     .0013     .0008    0.0000

              3 HV+LS          .0011     .0010     .0009     .0005     .0002    0.0000
                               .0007     .0007     .0006     .0005     .0003    0.0000
```





```
TOTALS       0.0000     .0102     .0252     .0536     .0751     .0921
LANE 1       0.0000     .0022     .0034     .0049     .0057     .0063

TOTALS        .0733     .0678     .0614     .0433     .0372     .0274
LANE 2        .0057     .0055     .0052     .0044     .0041     .0036

TOTALS        .0462     .0414     .0329     .0226     .0072    0.0000
LANE 3        .0046     .0043     .0039     .0032     .0018    0.0000
```

The Tuesday paired data for vehicles moving towards the shoulder generally confirms the Monday data.

```
                    INTERCHANGE 17 NORTH
                    ADVANCE ( G-2) SIGN (BEFORE)
                    9/21/71
                    0930-1430

5684                     1         2         3         4         5         6

          1 N       0.0000     .0084     .0206     .0294     .0424     .0567
                    0.0000     .0024     .0037     .0044     .0052     .0060

          1 HV      0.0000     .0007     .0012     .0021     .0032     .0063
                    0.0000     .0007     .0009     .0012     .0015     .0021

          1 LS      0.0000     .0004     .0026     .0042     .0051     .0063
                    0.0000     .0005     .0013     .0017     .0019     .0021

          1 HV+LS   0.0000    0.0000     .0005     .0009     .0007     .0009
                    0.0000    0.0000     .0006     .0009     .0007     .0008

VEHICLES  2 N        .0470     .0443     .0371     .0333     .0294     .0139
                     .0055     .0054     .0049     .0047     .0044     .0030

 MOVING   2 HV       .0055     .0060     .0046     .0058     .0044     .0040
                     .0019     .0020     .0018     .0020     .0017     .0017

 TOWARD   2 LS       .0060     .0067     .0048     .0032     .0023     .0012
                     .0020     .0021     .0018     .0015     .0012     .0009

SHOULDER  2 HV+LS    .0005     .0004     .0007     .0007     .0011     .0004
                     .0006     .0005     .0007     .0007     .0008     .0005

          3 N        .0211     .0164     .0137     .0079     .0011    0.0000    TOTALS    0.0000     .0095     .0250     .0366     .0514     .0702
                     .0037     .0033     .0030     .0023     .0008    0.0000    LANE 1    0.0000     .0025     .0041     .0049     .0057     .0066

          3 HV       .0049     .0019     .0016     .0011    0.0000    0.0000    TOTALS     .0589     .0574     .0471     .0429     .0371     .0195
                     .0017     .0011     .0010     .0008    0.0000    0.0000    LANE 2     .0061     .0060     .0055     .0053     .0049     .0036

          3 LS       .0049     .0040     .0018     .0009     .0002    0.0000    TOTALS     .0308     .0229     .0176     .0102     .0012    0.0000
                     .0018     .0017     .0011     .0008     .0003    0.0000    LANE 3     .0045     .0039     .0034     .0026     .0009    0.0000

          3 HV+LS    .0007     .0005     .0005     .0004    0.0000    0.0000
                     .0007     .0006     .0006     .0005    0.0000    0.0000
```

Summary. To summarize results across the approach to Interchange 17 North, a significant improvement in driver performance at the gore was found. There were dramatic reductions in erratic maneuvers under the diagrammatic signing condition. The proportion of vehicles traveling at least 5 mph below the mean speed for all vehicles was significantly reduced. This measure is related to accident likelihood (see Chapter V). Lane usage by both exiting and through traffic was significantly improved. Exiting traffic was more evenly distributed across the two instrumented lanes in the After phase.

Vehicular maneuvering was also reduced at the exit direction sign location. The data suggest that preparation for motorist action at the gore can be traced back to improved signing information at the advance sign. It should be pointed out that the advance sign in the Before phase provided no information to the motorist that the upcoming interchange involved a left exit whereas the diagrammatic advance sign in the After phase made this quite clear. Motorists apparently noticed and responded to this sign as shown by the increase in maneuvers, particularly through maneuvers, at this location within the tapeswitch array in the After phase.

Labor Day Study At Interchange 17 North[1]

The Labor Day Study resulted from an interest in the effects of diagrammatic signs under conditions of high proportions of out of state drivers, high traffic volumes and a wide range of traffic volumes. Out of state drivers were of interest because of their lack of familiarity with the roadway. Presumably, they would be more dependent on the signs, and more responsive to them than familiar motorists. The wide ranging volumes which occur on Labor Day provided the opportunity to study diagrammatic signs under conditions of relatively low volumes in the earlier hours, mid-range volumes just before noon, and high volumes in the afternoon.

Interchange 17 North was chosen because it is a left exit major fork. The two right lanes carry through I-495 traffic, and the two left lanes carry traffic to I-70S which continues to northern Maryland and is a well used route to Pennsylvania, New York, West Virginia and Ohio. Preliminary observation of erratic maneuvers at this interchange at the very beginning of this study showed that while this interchange is simple from an aerial point of view, it is complex from the driver's point of view. The proportion of foreign (out of state) vehicles which exit here is comparatively high, making it a good site for measuring the effects of diagrammatic signs on drivers who are not familiar with the roadway.

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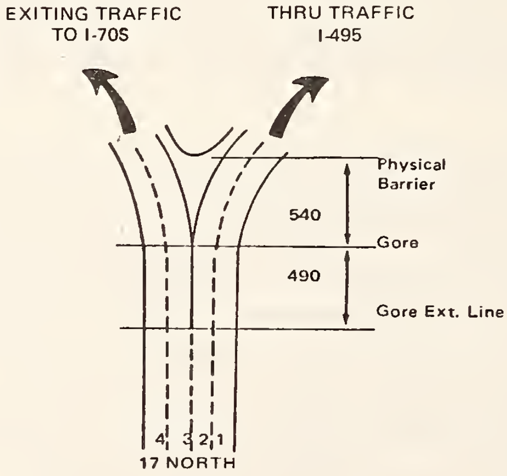
[1] The contributions of Jane Burnette to the analysis and preparation of this section are gratefully acknowledged.

Time-lapse cameras were positioned on the Bradley Boulevard overpass. One faced north, photographing the gore area, while the other faced south, photographing the exit direction (G-1) sign and the area downstream from it. Half-hour films were taken, with one hour intervals between films. This yielded six films per site for Labor Day 1971, and an equal number for 1972. Filming times were:

- 0940-1010
- 1100-1130
- 1230-1300
- 1400-1430
- 1530-1600
- 1700-1730

In addition, investigators counted vehicles and categorized them as foreign or local (on the basis of license plates) and by vehicle type: large truck, small truck or auto.

Results in the Gore Area. The gore area was divided into two zones, one of which encompassed the area from the physical barrier at the gore upstream to the tip of the painted gore (540 feet). The other zone extended from the tip upstream to the end of the painted gore extension line (490 feet). Results were tabulated separately for each zone as well as for both zones combined.



SCHEMATIC DIAGRAM OF THE 2 ZONES
WHERE ERRATIC MANEUVERS WERE SCORED

Figure 15 shows that weaves in the gore area, across both the painted gore and the gore extension line, declined in 1972. Averaging the percent of decline at each filming time yields a decline of about 43 percent. The lowest decline at any filming time was a 30 percent decrease and the highest was 50 percent. This reduction in gore weaves was not confined to one lane changing category; both through and exit samples showed substantial decrease.

Distribution Across Types of Lane Changes. Weaves to the right, or through weaves, showed the greatest decline. Per thousand through vehicles, about 72 made this type of lane change on Labor Day 1971.[1] After diagrammatic signs were in place, that average dropped to about 39 per thousand on Labor Day 1972. This is an average decline of about 45 percent.

Measures of weaves to the left, made by exiting vehicles, yielded similar results with an average of 36 weaves per thousand exiting vehicles in 1971 as compared to 23 per thousand on Labor Day 1972. The average decline in weaves left is about 34 percent.

Other lane changes also dropped from 65 per thousand total volume under conventional signing to 45 per thousand under diagrammatics. For specific numbers of weaves and lane changes during the time intervals tested, refer to Figure 15. There is wide variability in the numbers between types of weaves. The reader should note the ordinate scale when comparing graphs.

Distribution Across Zones. In addition to occurring in both the "through" and "exiting" categories, the decrease in weaves was also distributed across zones, i.e., weaves decreased not only over the painted gore but also over the gore extension line. Figure 16 shows the extent of the decrease between Labor Day 1971 and 1972 in total weaves (through plus exit) over the painted gore. Averaging the weaves per thousand total volume yields about 25 weaves per thousand for 1971 and about 11 weaves per thousand for 1972. At this location alone, through traffic was affected only slightly more than exit, with decreases of 55 percent and 50 percent, respectively (see Figure 16 for weaves per 1000 vehicles). Other lane changes also dropped from about 35 per thousand total volume to 20 per thousand.

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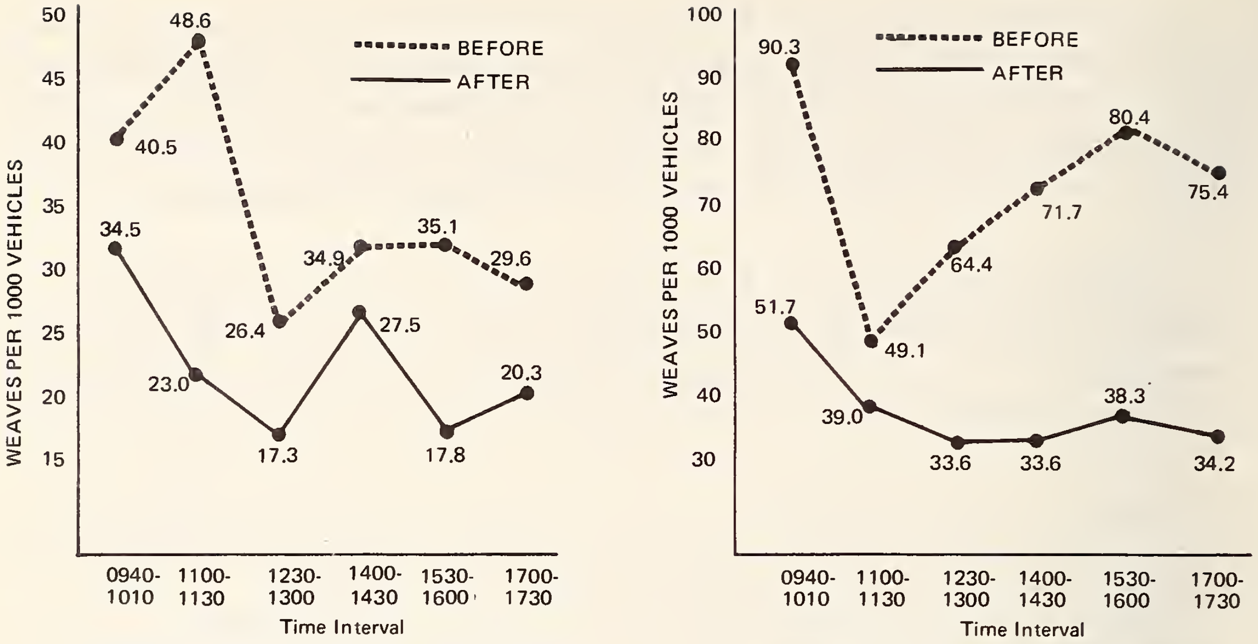
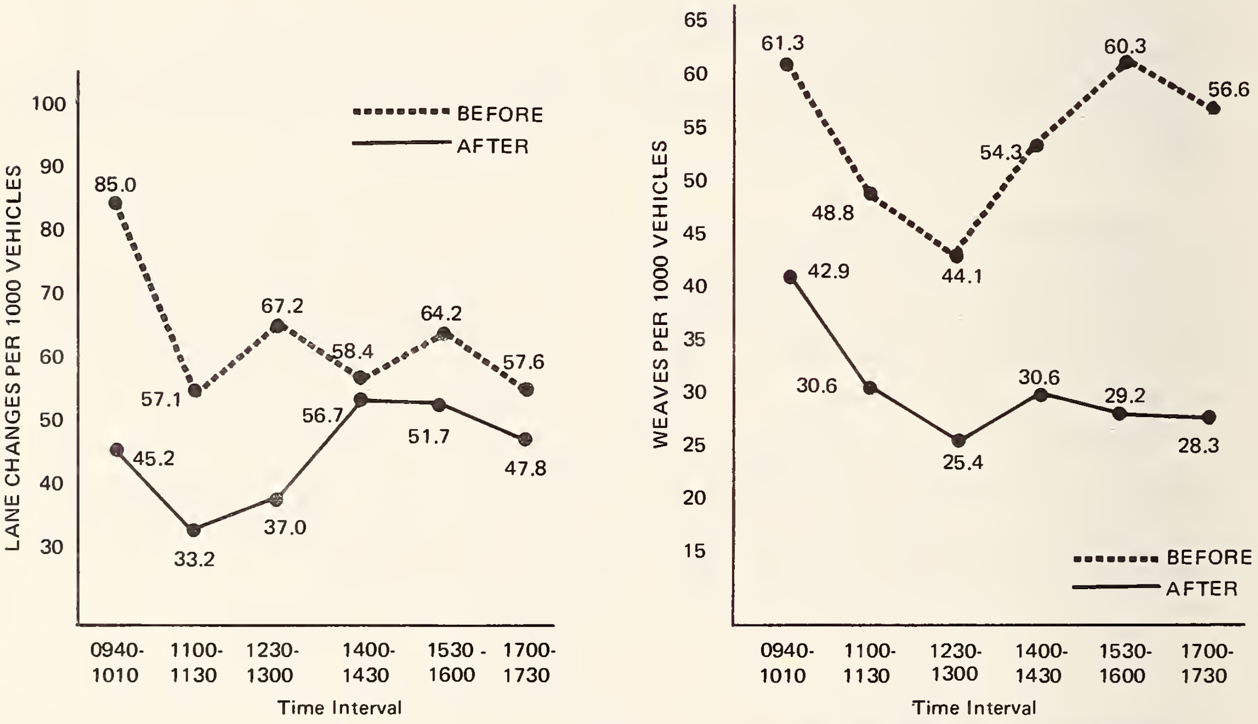
[1] This is an average of weaves per thousand vehicles at each filming time. Throughout this section, average weaves per thousand are computed by this method. Average declines are computed on the difference between Before (1971) weaves per thousand vehicles and After (1972) weaves per thousand at each filming interval. These six differences are then averaged, yielding average decline.



WEAVES LEFT PER 1000 EXITING VEHICLES

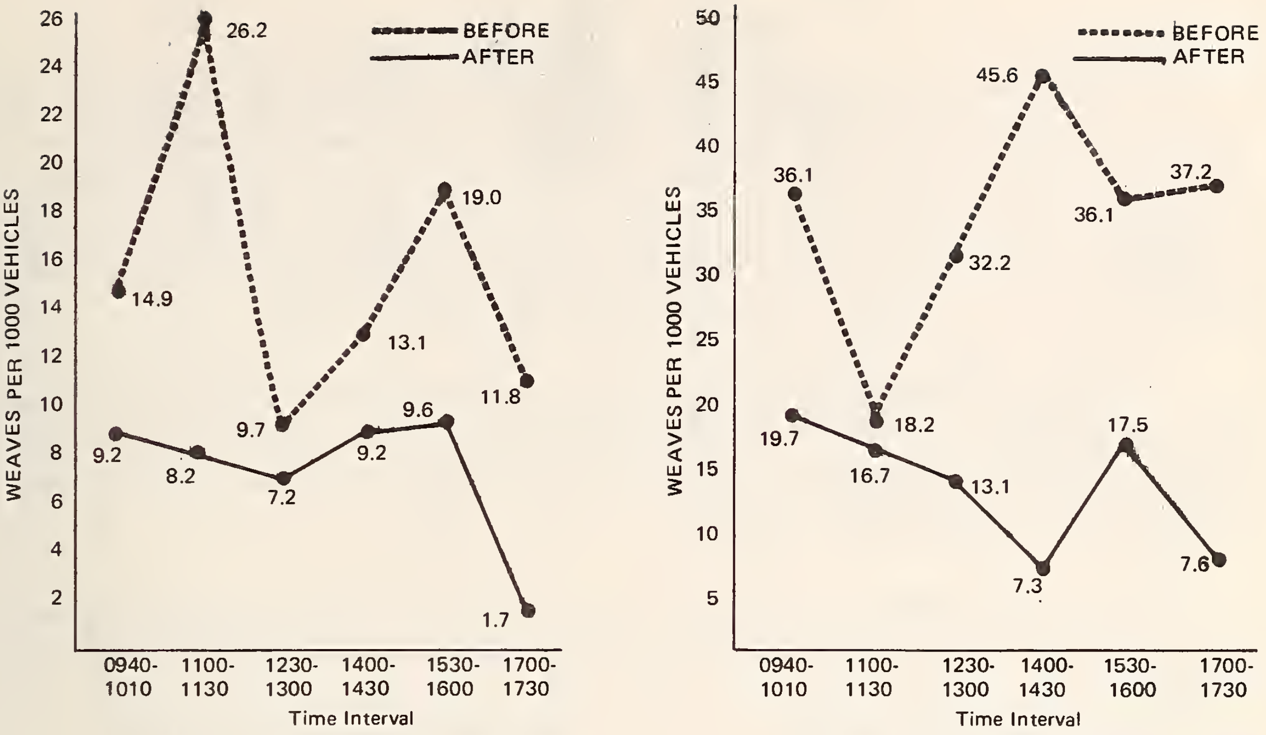
WEAVES RIGHT PER 1000 THRU VEHICLES



OTHER LANE CHANGES PER 1000 TOTAL VOLUME

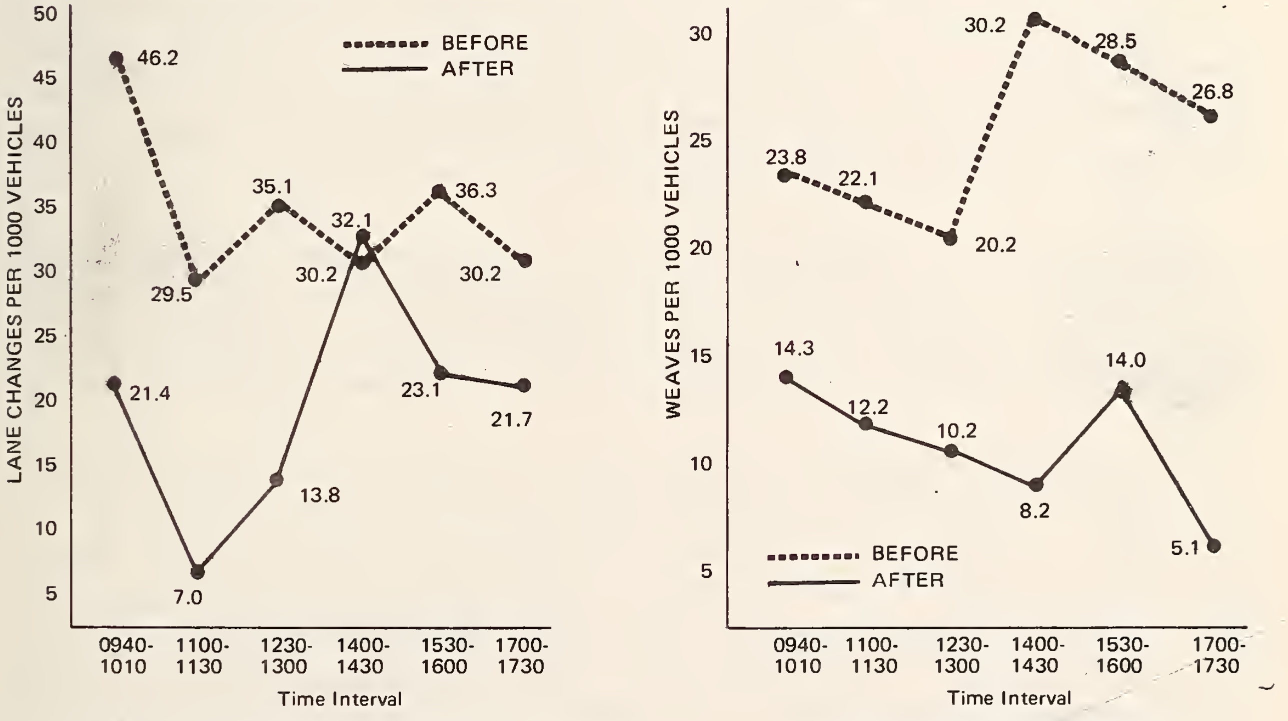
WEAVES LEFT AND WEAVES RIGHT PER 1000 TOTAL VOLUME

Figure 15. Total maneuvers in gore area: maneuvers over painted gore and over painted gore extension line (summed from Figures 16 and 17).



WEAVES LEFT PER 1000 EXITING VEHICLES

WEAVES RIGHT PER 1000 THRU VEHICLES



OTHER LANE CHANGES PER 1000 TOTAL VOLUME

WEAVES LEFT PLUS WEAVES RIGHT PER 1000 TOTAL VOLUME

Figure 16. Maneuvers over painted gore.

At the gore extension line, the pattern is again evident. Through traffic showed an average decrease in weaves of about 33 percent, while the exit traffic decrease in weaves was about 23 percent. In terms of vehicles per thousand through volume, through weaves (to the right) dropped from 38 in 1971 to 25 in 1972. Exit weaves (to the left) per thousand exiting vehicles dropped from 20 to 16. Other lane changes (per thousand total volume) again decreased from 30 to 25. These declines are shown in Figure 17.

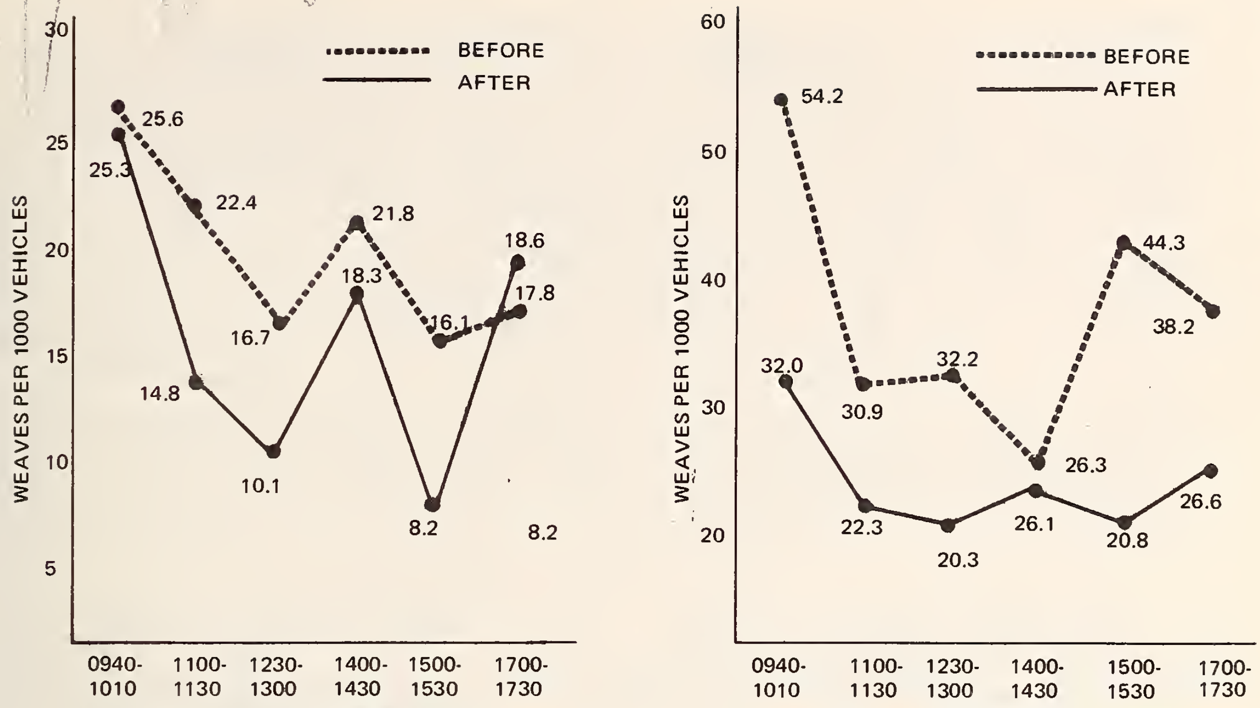
Distribution Across Filming Intervals (Time). Maneuvers in the total gore area (through plus exit) generally decreased between 0940 and 1230, then rose in the afternoon (see Figure 15). Other lane changes reflected this trend in 1972, but on Labor Day 1971, they continued to decline in the afternoon hours.

Results at the Exit Direction (G-1) Sign. Lane changes at G-1 were categorized as preparatory maneuvers, through maneuvers, and other lane changes, all expressed per thousand total volume.

Preparatory maneuvers (changes to the left over the midline) dropped from an average of 12 per thousand total volume in 1971 to about three per thousand in 1972 at this location. The change in through maneuvers (right over midline) was not as great as the decline at the gore. The through maneuvers dropped from 35 per thousand to about 16 per thousand. Other lane changes also dropped from 66 per thousand to 32 per thousand.

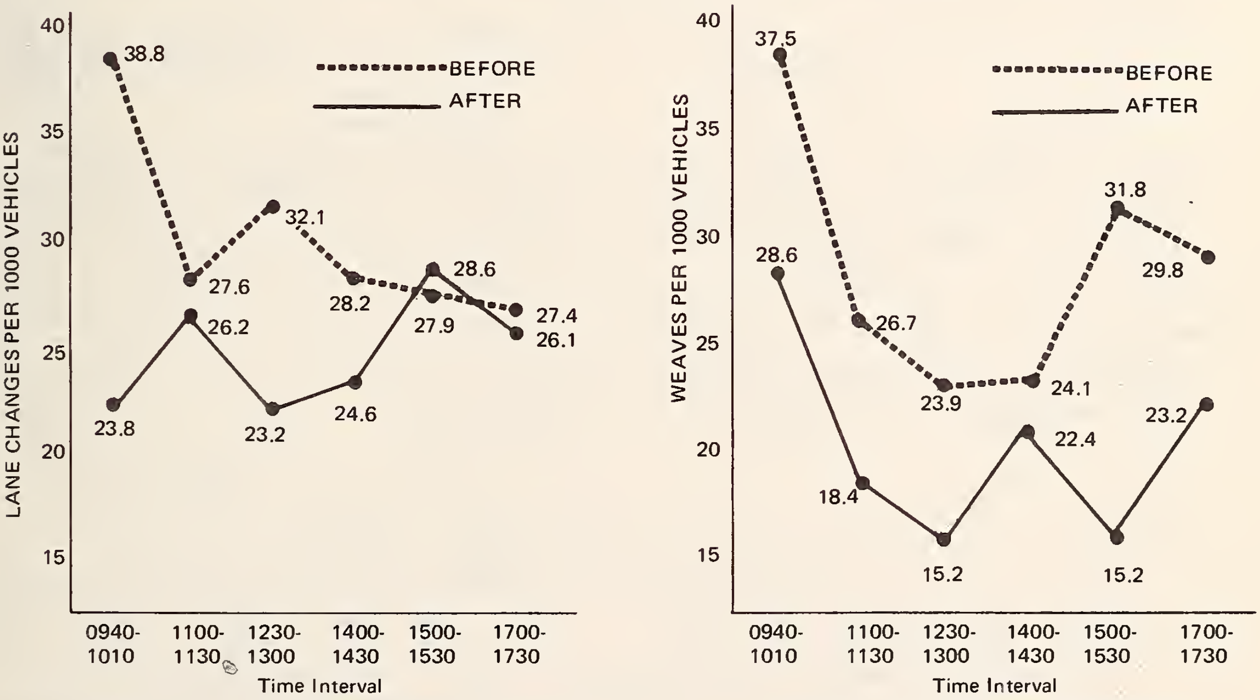
Time trends were not as uniform here as they were in the gore area. In general, the 1971 data shows a morning drop with an early afternoon peak, then declines again in late afternoon. "Other Lane Changes" is the only category which rises again in the afternoon. These differences between the 1971 and 1972 Labor Day data are illustrated in Figure 18.

Sample Characteristics. Total traffic volume rose throughout both days, from about 800 vehicles in the first filming interval (0940-1010) to a peak of around 1650 (Figure 19) vehicles. This peak was reached in the last filming interval (1700-1730) of the Before phase and at the 1530-1600 interval of the After phase. Exiting volume showed an opposite trend, dropping as the day wore on. Data collected by manual counting showed that the percentage of foreign vehicles also dropped in a curve whose shape resembles the curve of exiting volume (see Figure 19). About half of the local and foreign populations exited (not shown in Figure 19). The foreign population made up about one-fourth of the total population; therefore, it also comprised about one-fourth of the exiting population. Similarly, roughly one-fourth of through vehicles were from states other than Maryland, Virginia and the District of Columbia.



WEAVES LEFT PER 1000 EXITING VEHICLES

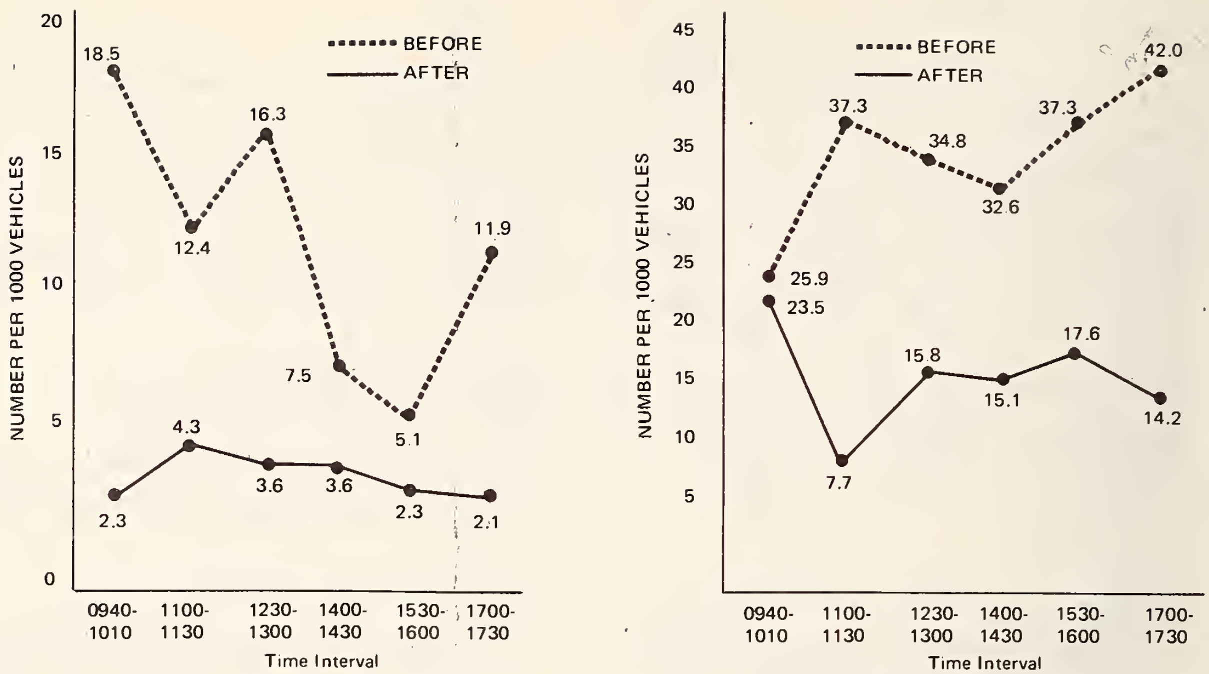
WEAVES RIGHT PER 1000 THRU VEHICLES



OTHER LANE CHANGES PER 1000 TOTAL VOLUME

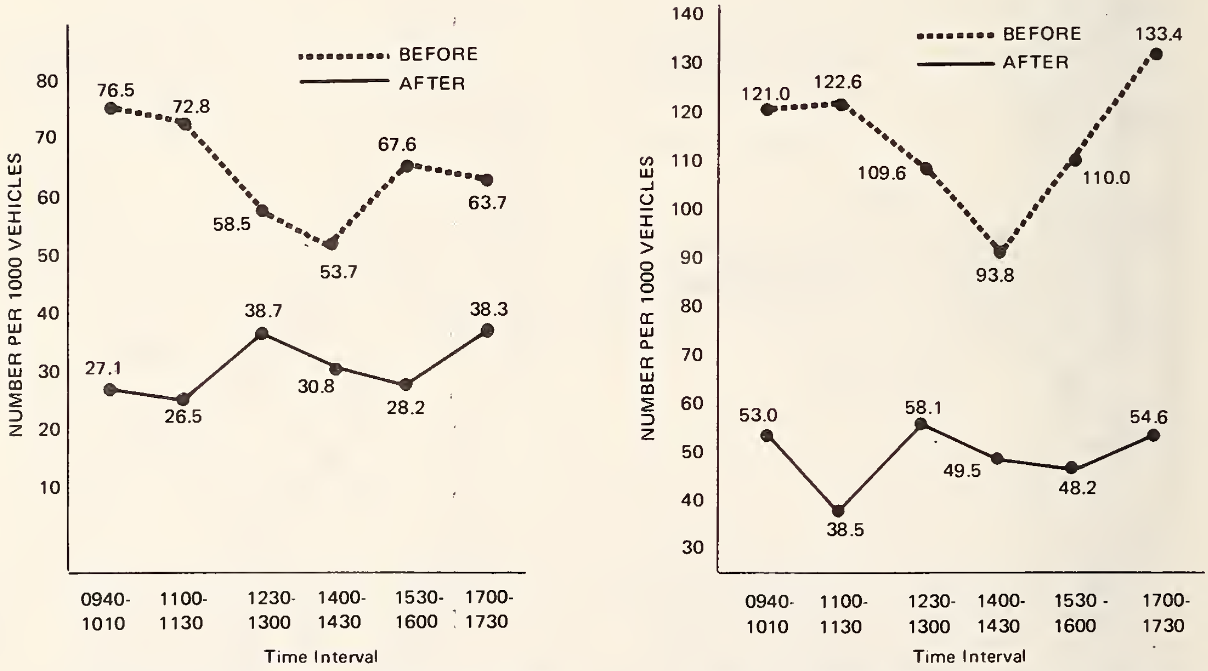
WEAVES LEFT PLUS WEAVES RIGHT PER 1000 TOTAL VOLUME

Figure 17. Maneuvers over painted gore extension line.



PREPARATORY MANEUVERS PER 1000 TOTAL VOLUME

THRU MANEUVERS PER 1000 TOTAL VOLUME



OTHER LANE CHANGES PER 1000 TOTAL VOLUME

TOTAL LANE CHANGES PER 1000 TOTAL VOLUME

Figure 18. Lane changes at the exit direction sign.

The time trends which have been mentioned can be related to the rise in traffic volume. As volume increases, the number of lane changes tends to decrease, especially in the category of "Other Lane Changes." For example, other lane changes in the area of the painted gore show peaks and lows opposite to those shown in traffic volume. This trend is most apparent in the gore area, less evident at the gore extension line, and least apparent at the G-1 sign. The idea that high volume suppresses lane changing is a logical one, because as traffic reaches a certain density, available space in the desired lane decreases. It is also logical that "Other Lane Changes," which do not change final destination, would be most affected.

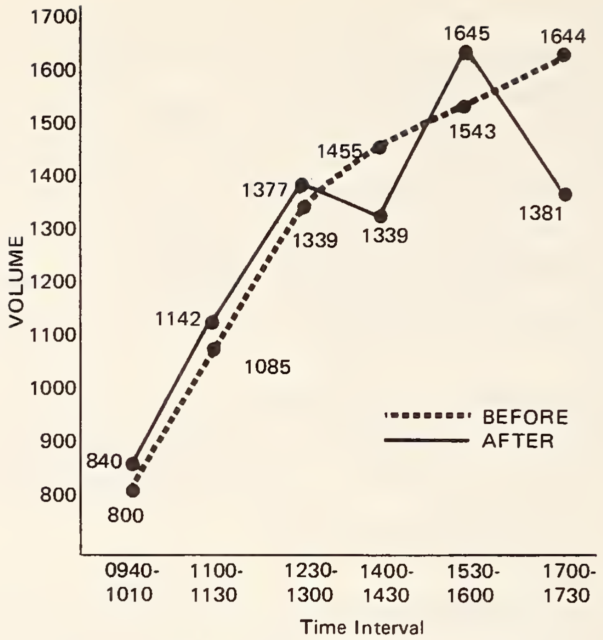
The decline in all types of lane changing under diagrammatic signing, however, cannot be attributed to differences in traffic volumes. Figure 19 shows that there was not a significant difference in volumes on Labor Day 1971 as compared to 1972. The percentages of foreign and exiting vehicles also remained about the same.

It should be noted that it rained the morning of Labor Day 1972, and stopped before the 1230 filming whereas weather was clear and sunny throughout Labor Day 1971. The decline in weaves is not a result of this weather change. Both morning and afternoon data show a substantial difference in weaves. The fact that the results are consistent across lane changing categories, location (painted gore and gore extension line) and time preclude their explanation by changes in the above mentioned variables.

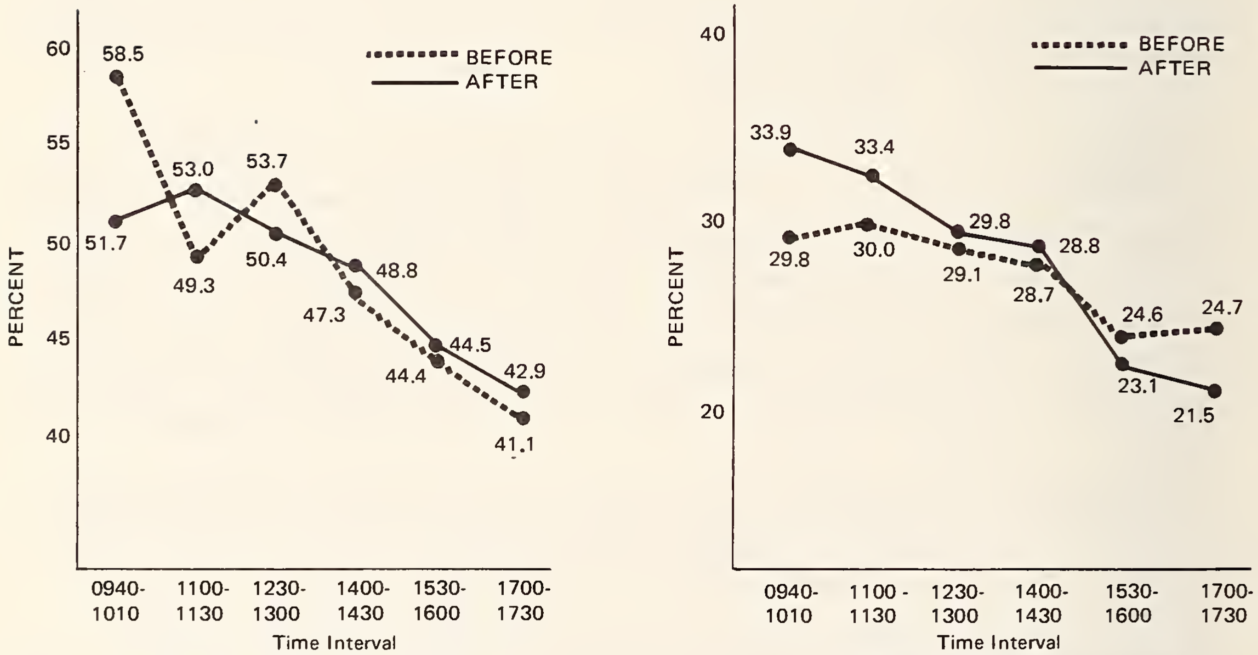
It has been indicated that at the gore, through traffic showed a greater decrease in weaves than exiting traffic. This was the case both at the gore and at the gore extension line. This is a left exit interchange; the driver must keep right to avoid exiting, a behavior which is opposite that required at most interchanges. It is apparent that the diagrammatic signs erected at this interchange conveyed that information in a manner which enabled the through driver to either position himself in a right-hand lane earlier or stay in a right-hand lane, instead of positioning himself in one of the left lanes, which are through lanes at most interchanges.

The exiting driver is more likely to be looking for his preferred exit and seeking information about it. The data show that diagrammatics provide this information in a form which is understood better than conventional signing at this interchange.

The results of the Labor Day study with time-lapse photography confirm the results of the main Before/After study as measured by the TES. Weaving maneuvers at the gore area were reduced dramatically for both exiting and through traffic in both studies. The Labor Day study provides further evidence that both preparatory and through maneuvers were reduced at



LABOR DAY VOLUMES AT 17N GORE



PERCENTAGE OF EXITING TRAFFIC

PERCENT OF FOREIGN VEHICLES

Figure 19. Schematic diagram, total volumes, percentage of exiting traffic and percentage of foreign vehicles at six time intervals on Labor Day.

the exit direction sign. Vehicle maneuvering which accounts for the reduction in weaving at the gore may be occurring between the G-1 location and the gore. More likely, however, in view of the advance (G-2) sign data in the main Before/After study, much of this maneuvering may be occurring near the G-2 sign or between it and the G-1 sign. In any case, vehicles are positioning themselves more advantageously in advance of the gore itself.

Democracy Boulevard

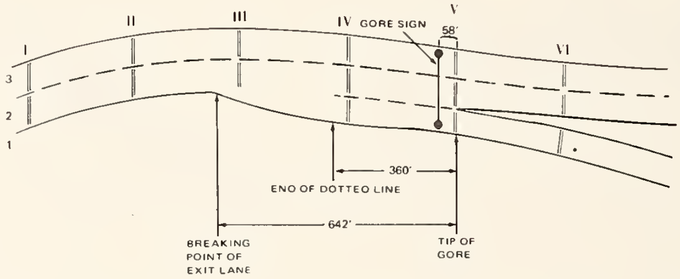
The Democracy Boulevard interchange on I-70S is encountered by the northbound motorist about one-half mile after he exits from I-495 at Interchange 17 North. The Democracy Boulevard interchange is a partial cloverleaf. There are two right-hand exits from the northbound through road.

The approach is two lanes wide and is signed at the advance, exit direction, and both gore locations. Of the test interchanges, this one is exceptional in that one of the signs on the approach was not changed. This was the advance sign which remained conventional throughout the study.

Data were collected by means of the TES at the first gore and by time-lapse films at the other three locations. Results at the first gore are presented first, followed by results at the second gore, at the exit direction location, and at the advance sign.

First Gore (Democracy Boulevard East). Tapeswitch instrumentation at this gore is diagrammed below. Both through lanes were instrumented. Tapeswitches were also deployed in the deceleration lane and beginning of the exit ramp. The deceleration lane and exit ramp are labeled Lane 1. The two through lanes are labeled Lanes 2 and 3 from the shoulder to the median, respectively.

Democracy Blvd. Gore



The range in percentage hourly volume (measured at Trap 6) for exiting and through traffic collected over the four days (two in the Before phase, two in the After phase), was as shown below:

	Total	Auto	Nonauto
Lane 1 (Exiting)	10-13	10-13	5- 7
Lane 2 (Through)	49-52	46-49	76-82
Lane 3 (Through)	36-41	38-43	13-18

As can be seen, about ten percent of the traffic exited at the first exit for Democracy Boulevard. Proportionately more autos exited than nonautos. Most of the traffic used Lane 2, particularly the nonauto traffic.

The mean absolute speeds of all vehicles and those coded as local or nonlocal during the day that manual coding was done in the Before phase (August 24, 1971) and in the After phase (August 22, 1972), are shown on the following page. The number of local and nonlocal vehicles does not sum to the total vehicles shown because manual coding was not continuous during the day but was interrupted by 15-minute breaks. Data on the two other days sampled in the Before (August 23, 1971) and After (August 21, 1972) phase were similar to those shown.

There is little difference in speed between the Before and After phases nor between local and nonlocal vehicles. Vehicles entering the decleration lane traveled about five miles slower than their neighbors in Lane 2, and 11 to 12 miles slower than vehicles in Lane 3. Compared to the average entry speed at Trap 1 in Lane 2, vehicles slowed about five miles below this speed when entering the deceleration lane.

```
                                                   DEMOCRACY BLVD.
                                                   GORE SIGN (BEFORE)
                                                   8/24/71
                                                   0930-1430

                        TRAP 1              TRAP 2              TRAP 3              TRAP 4              TRAP 5              TRAP 6
                             NON-                NON-                NCN-                NON-                NCN-                NON-
ABSOLUTE SPEED     TOTAL LOCAL LOCAL   TOTAL LOCAL LOCAL   TOTAL LCCAL LCCAL   TOTAL LOCAL LOCAL   TOTAL LCCAL LCCAL   TOTAL LOCAL LOCAL

 LANE 1
   N                   0     0     0       0     0     0       0     0     0     604   241     7     692   286     9     686   284     9
   MEAN             0.00  0.00  0.00    0.00  0.00  0.00    0.00  0.00  0.00   50.89 51.38 49.99   43.74 43.88 43.42   40.93 40.70 40.89
   STAND DEV        0.00  0.00  0.00    0.00  0.00  0.00    0.00  0.00  0.00    5.28  4.84  4.70    4.98  4.58  4.52    6.38  6.35  6.22
   SKEWNESS         0.00  0.00  0.00    0.00  0.00  0.00    0.00  0.00  0.00    -.28  -.01  -.98    -.06  -.17   .12    -.42  -.63   .49
   KURTOSIS         0.00  0.00  0.00    0.00  0.00  0.00    0.00  0.00  0.00    3.71  2.74  3.18    3.14  2.57  2.67    3.59  3.71  2.24

 LANE 2
   N                3511  1418   114    3499  1412   115    3460  1397   115    2871  1161   112    2786  1114   110    2775  1108   107
   MEAN            55.97 56.05 57.06   56.66 56.77 57.76   56.36 56.42 57.71   55.92 55.94 56.82   55.95 55.97 56.82   55.47 55.44 56.26
   STAND DEV        6.28  6.16  6.19    6.27  6.09  5.85    6.37  6.23  6.32    6.16  6.06  6.35    6.28  6.21  6.45    6.64  6.68  6.79
   SKEWNESS         -.31  -.33   .02    -.43  -.40  -.12    -.41  -.39   .05    -.21  -.22  -.19    -.33  -.42  -.17    -.62 -1.06  -.13
   KURTOSIS         5.00  5.04  2.91    5.08  5.18  3.02    4.70  5.03  3.02    3.83  3.82  2.83    4.40  4.92  2.81    6.88 10.50  2.55

 LANE 3
   N                1890   733    92    1902   739    91    1941   754    91    1926   749    87    1923   751    87    1940   759    90
   MEAN            62.61 62.79 62.93   63.41 63.67 64.10   63.04 63.35 63.50   62.84 63.07 62.92   62.65 62.82 62.76   63.01 63.12 63.30
   STAND DEV        4.99  4.91  4.88    5.06  5.09  4.64    5.12  5.11  4.53    5.19  5.21  4.84    5.13  5.11  4.94    5.41  5.53  5.13
   SKEWNESS         -.37  -.26  -.50    -.30  -.35  -.25    -.18  -.11  -.17    -.28  -.17  -.30    -.31  -.17  -.34    -.57  -.98  -.49
   KURTOSIS         4.32  4.07  3.45    4.17  4.38  3.38    3.91  3.63  3.61    4.37  4.02  3.42    4.16  3.60  3.58    7.26 10.11  3.71


                                                   DEMOCRACY BLVD.
                                                   GORE SIGN (AFTER)
                                                   8/22/72
                                                   0930-1430

                        TRAP 1              TRAP 2              TRAP 3              TRAP 4              TRAP 5              TRAP 6
                             NON-                NON-                NON-                NON-                NON-                NON-
ABSOLUTE SPEED     TOTAL LOCAL LOCAL   TOTAL LOCAL LOCAL   TOTAL LOCAL LOCAL   TOTAL LOCAL LOCAL   TOTAL LOCAL LOCAL   TOTAL LOCAL LOCAL

 LANE 1
   N                   0     0     0       0     0     0       0     0     0     607   368    24     651   392    32     645   387    32
   MEAN             0.00  0.00  0.00    0.00  0.00  0.00    0.00  0.00  0.00   51.60 51.54 50.43   44.36 44.36 43.39   42.57 42.58 42.80
   STAND DEV        0.00  0.00  0.00    0.00  0.00  0.00    0.00  0.00  0.00    5.38  5.21  5.63    5.17  5.05  5.12    5.06  5.11  3.50
   SKEWNESS         0.00  0.00  0.00    0.00  0.00  0.00    0.00  0.00  0.00     .20  -.01  -.14    -.02  -.12  -.57    -.74 -1.26  -.02
   KURTOSIS         0.00  0.00  0.00    0.00  0.00  0.00    0.00  0.00  0.00    3.79  3.60  2.27    3.62  4.00  4.37    8.20 10.88  3.03

 LANE 2
   N                3765  2175   389    3717  2159   390    3653  2133   370    3108  1807   350    3029  1752   339    3000  1734   338
   MEAN            57.10 57.16 56.64   57.26 57.26 56.80   56.35 56.32 56.02   56.49 56.56 56.03   56.74 56.89 56.39   56.39 56.59 56.40
   STAND DEV        6.09  6.01  6.11    5.96  5.90  6.09    5.95  5.92  5.99    5.94  5.88  6.08    5.80  5.72  6.07    6.39  6.25  6.12
   SKEWNESS         -.10  -.33  -.49    -.18  -.30  -.40    -.06  -.19  -.39    -.11  -.15  -.34    -.12  -.11  -.40    -.96  -.98  -.50
   KURTOSIS         4.12  4.28  4.00    3.92  4.06  3.50    3.70  3.68  3.41    3.55  3.56  3.21    3.76  3.71  3.19    8.79  9.01  3.76

 LANE 3
   N                2394  1394   324    2442  1410   333    2506  1436   343    2444  1394   339    2479  1425   342    2514  1448   343
   MEAN            64.14 64.17 64.07   64.33 64.36 64.29   63.43 63.50 63.53   63.09 63.19 63.06   62.64 62.82 62.92   63.37 63.36 63.57
   STAND DEV        6.82  6.49  6.23    5.26  5.07  5.43    5.13  4.95  5.29    5.22  4.98  5.64    5.23  5.18  5.40    5.45  5.55  5.64
   SKEWNESS        -2.51 -2.36 -1.93    -.34  -.09  -.25    -.22  -.09  -.32    -.24  -.01  -.91    -.24  -.33  -.40    -.68 -1.17   .20
   KURTOSIS        20.12 20.77 19.18    5.23  4.26  5.47    4.34  4.25  4.30    4.78  4.04  7.18    5.19  6.11  3.61   16.12 22.30  8.06
```

The following tables show the proportions of vehicles meeting the various criteria defined in Chapter V. Before phase data are presented in the left-hand columns; After phase data in the right-hand columns. It should be noted that the sample size on one of the Before phase days (August 23, 1971) is about one-fifth that of other days. This is because technical difficulties reduced the total data collection period to the first hour of the five-hour data collection interval (0930 to 1430).

Lane placement of the exiting and through vehicle populations is shown last.

Data within each table (or each set of Before and After tables for lane placement data) are paired by weekday. In other words, the first table shows data collected on August 24, 1971 and August 22, 1972, both Tuesday.

Each table is accompanied by annotations highlighting features of the table.

		DEMOCRACY BLVD. GORE SIGN (BEFORE) 8/24/71 0930-1430	DEMOCRACY BLVD. GORE SIGN (AFTER) 8/22/72 0930-1430							
		AUTOS	AUTOS		NONAUTOS	NONAUTOS		ALL	ALL	
		4962	5642		439	517		5401	6159	
1.	SPEED DIFFERENCE	.17251 .01051	.15987 .00956	N.S.	.41686 .04612	.35783 .04132	N.S.	.19237 .01051	.17649 .00952	↓
2.	HEADWAY VIOLATION	.13019 .00936	.13648 .00896	N.S.	.04328 .01904	.10058 .02593	↑	.12313 .00876	.13346 .00849	N.S.
3.	HAZARDOUS MANUEVERS	.01169 .00299	.00603 .00202	↓	.00456 .00630	.00193 .00379	N.S.	.01111 .00280	.00568 .00188	↓
4.	1 + 2	.08726 .00785	.08065 .00711	N.S.	.10478 .02865	.07930 .02329	N.S.	.08869 .00758	.08053 .00680	N.S.
5.	2 + 3	.00403 .00176	.00142 .00098	↓	0.00000 0.00000	.00193 .00379		.00370 .00162	.00146 .00095	↓
6.	1 + 3	.00947 .00270	.00567 .00196	↓	.01367 .01086	.00774 .00755	N.S.	.00981 .00263	.00585 .00190	↓
7.	1 + 2 + 3	.00625 .00219	.00053 .00060	↓	.00228 .00446	0.00000 0.00000		.00592 .00205	.00049 .00055	↓
8.	NORMAL	.57860 .01374	.60936 .01273	↑	.41458 .04609	.45068 .04289	N.S.	.56527 .01322	.59604 .01225	↑
9.	DBL LANE CHANGES	.00947 .00270	.00514 .00187	↓	.00683 .00771	0.00000 0.00000		.00926 .00255	.00471 .00171	↓

Most of the significant differences are in hazardous maneuvers committed by autos either alone or in combination with the other criteria. A significant reduction in hazardous maneuvers of autos is shown. A similar trend appears for nonautos but the differences are not significant.

DEMOCRACY BLVD.
GORE SIGN (BEFORE)
8/23/71
0930-1030

DEMOCRACY BLVD.
GORE SIGN (AFTER)
8/21/72
0930-1430

		AUTOS	AUTOS		NONAUTOS	NONAUTOS		ALL	ALL	
		1041	5211		95	441		1136	5652	
1.	SPEED DIFFERENCE	.14601 .02145	.18979 .01065	↑	.43158 .09960	.40136 .04575	N.S.	.16989 .02184	.20630 .01055	↑
2.	HEADWAY VIOLATION	.11720 .01954	.12339 .00893	N.S.	.08421 .05584	.07256 .02421	N.S.	.11444 .01851	.11943 .00845	N.S.
3.	HAZARDOUS MANUEVERS	.00576 .00460	.00557 .00202	N.S.	0.00000 0.00000	0.00000 0.00000		.00528 .00422	.00513 .00186	N.S.
4.	1 + 2	.06916 .01541	.08732 .00766	↑	.07368 .05254	.07256 .02421	N.S.	.06954 .01479	.08616 .00732	↑
5.	2 + 3	0.00000 0.00000	.00288 .00145		0.00000 0.00000	0.00000 0.00000		0.00000 0.00000	.00265 .00134	
6.	1 + 3	.00576 .00460	.00691 .00225	N.S.	0.00000 0.00000	.00680 .00767		.00528 .00422	.00690 .00216	N.S.
7.	1 + 2 + 3	.00288 .00326	.00230 .00130	N.S.	0.00000 0.00000	0.00000 0.00000		.00264 .00298	.00212 .00120	N.S.
8.	NORMAL	.65322 .02891	.58185 .01339	↓	.41053 .09892	.44671 .04640	N.S.	.63292 .02803	.57130 .01290	↓
9.	DEL LANE CHANGES	.00576 .00460	.00806 .00243	N.S.	0.00000 0.00000	0.00000 0.00000		.00528 .00422	.00743 .00224	N.S.

The reduction in hazardous maneuvers committed by autos found for the two matched days presented in the preceding table is not found for the two matched days presented in this table. There is also a significant decrease in the proportion of vehicles falling into the normal category rather than a significant increase. A possible explanation is the sampling period in the Before phase.

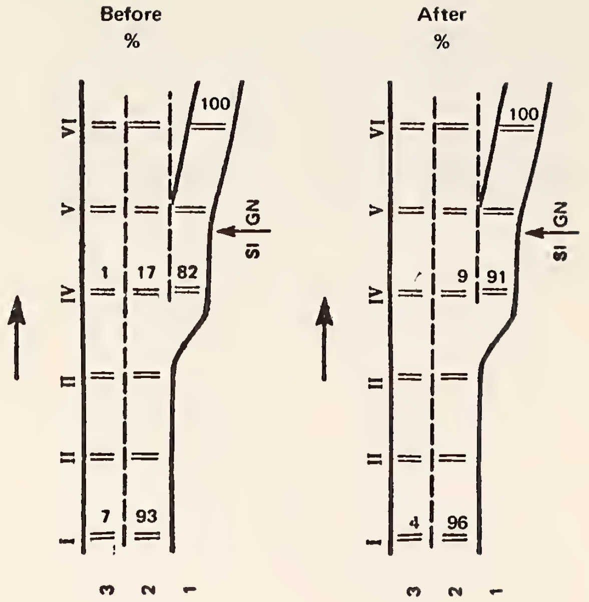
DEMOCRACY BLVD. GORE SIGN (BEFORE) 8/24/71 0930-1430	DEMOCRACY BLVD. GORE SIGN (AFTER) 8/22/72 0930-1430

		LOCAL	LOCAL		FOREIGN	FOREIGN		ALL	ALL	
		2151	3569		206	713		2357	4282	
1.	SPEED DIFFERENCE	.18364 .01636	.16615 .01221	N.S.	.23301 .05773	.18373 .02843	N.S.	.18795 .01577	.16908 .01123	N.S.
2.	HEADWAY VIOLATION	.13389 .01439	.14766 .01164	N.S.	.06311 .03321	.08415 .02038	N.S.	.12770 .01347	.13709 .01030	N.S.
3.	HAZARDOUS MANUEVERS	.01209 .00462	.00560 .00245	↓	.00971 .01339	.00701 .00613	N.S.	.01188 .00437	.00584 .00228	↓
4.	1 + 2	.09159 .01219	.08406 .00910	N.S.	.05340 .03070	.06452 .01803	N.S.	.08825 .01145	.08080 .00816	N.S.
5.	2 + 3	.00232 .00204	.00196 .00145	N.S.	.00485 .00949	0.00000 0.00000		.00255 .00203	.00163 .00121	N.S.
6.	1 + 3	.01162 .00453	.00448 .00219	↓	0.00000 0.00000	.01262 .00819		.01061 .00414	.00584 .00228	↓
7.	1 + 2 + 3	.00511 .00301	.00084 .00095	↓	.00485 .00949	0.00000 0.00000		.00509 .00287	.00070 .00079	↓
8.	NORMAL	.55974 .02098	.58924 .01614	↑	.63107 .06589	.64797 .03506	N.S.	.56597 .02001	.59902 .01468	↑
9.	DBL LANE CHANGES	.00883 .00395	.00588 .00251	N.S.	.00971 .01339	.00561 .00548	N.S.	.00891 .00379	.00584 .00228	N.S.

A reduction in hazardous maneuvers for local vehicles similar to that found for autos on the same day is shown in the above table. The proportion of normal vehicles also increased. Since autos comprise the majority of the sample population, this is to be expected.

DEMOCRACY BLVD.
GORE SIGN (AFTER)
8/22/72
0930-1430

EXIT TRAFFIC 645	TRAP 1	2	3	4	5	6
1 N	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.7333 .0341	.8264 .0292	.8295 .0290
1 HV	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.0295 .0133	.0341 .0140	.0264 .0124
1 LS	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.1333 .0262	.1271 .0257	.1302 .0260
1 HV+LS	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.0124 .0085	.0078 .0068	.0140 .0091
2 N	.6512 .0368	.6403 .0370	.6031 .0378	.0558 .0177	.0016 .0030	0.0000 0.0000
2 HV	.1116 .0243	.1333 .0262	.1442 .0271	.0016 .0030	0.0000 0.0000	0.0000 0.0000
2 LS	.1488 .0275	.1473 .0274	.1829 .0298	.0295 .0130	.0016 .0030	0.0000 0.0000
2 HV+LS	.0465 .0163	.0481 .0165	.0543 .0175	.0016 .0030	0.0000 0.0000	0.0000 0.0000
3 N	.0279 .0127	.0233 .0116	.0124 .0095	.0016 .0033	.0016 .0030	0.0000 0.0000
3 HV	.0062 .0061	.0031 .0043	.0016 .0030	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
3 LS	.0062 .0061	.0031 .0043	.0016 .0030	.0016 .0030	0.0000 0.0000	0.0000 0.0000
3 HV+LS	.0016 .0030	.0016 .0033	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

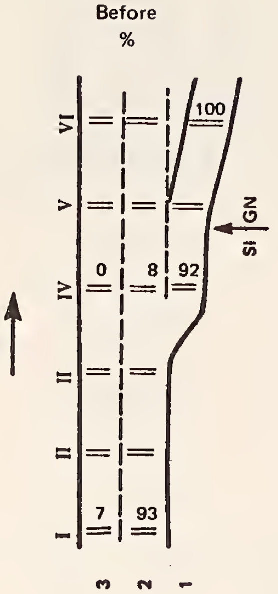


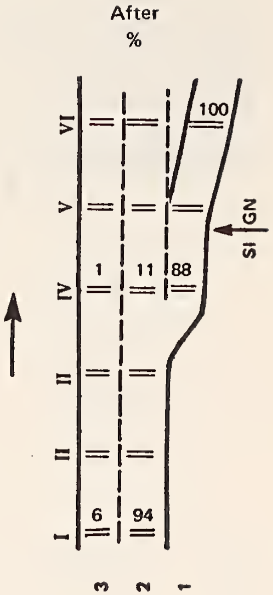
TOTALS LANE 1	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.9085 ↑ .0222	.9953 .0053	1.0000 0.0000
TOTALS LANE 2	.9581 ↑ .0155	.9690 .0134	.9845 .0095	.0884 ↓ .0219	.0031 .0043	0.0000 0.0000
TOTALS LANE 3	.0419 ↓ .0155	.0310 .0134	.0155 .0095	.0031 N.S. .0043	.0016 .0033	0.0000 0.0000

Lane placement of exiting traffic for the Tuesday paired Before/After data collection periods suggests an improvement in the After phase. A significantly greater proportion of vehicles entered the deceleration lane promptly and a significantly higher proportion of exiting vehicles entered the array in the right-hand lane. (Significance test results are shown at Traps 1 and 4 only.)

```
                 DEMOCRACY BLVD.
                 GORE SIGN (BEFORE)
                 8/24/71
                 0930-1430

EXIT TRAFFIC                           TRAP
    686                  1       2       3       4       5       6

          1 N        0.0000  0.0000  0.0000   .6647   .8149   .8586
                     0.0000  0.0000  0.0000   .0353   .0291   .0261

          1 HV       0.0000  0.0000  0.0000   .0204   .0233   .0466
                     0.0000  0.0000  0.0000   .0106   .0113   .0158

          1 LS       0.0000  0.0000  0.0000   .1297   .1429   .0816
                     0.0000  0.0000  0.0000   .0251   .0262   .0205

          1 HV+LS    0.0000  0.0000  0.0000   .0087   .0117   .0131
                     0.0000  0.0000  0.0000   .0070   .0080   .0085

          2 N         .6356   .6093   .6035   .0875   .0029  0.0000
                      .0360   .0365   .0366   .0211   .0040  0.0000

          2 HV        .0962   .1137   .1064   .0058  0.0000  0.0000
                      .0221   .0238   .0231   .0057  0.0000  0.0000

          2 LS        .1501   .1647   .2070   .0700   .0044  0.0000
                      .0267   .0278   .0303   .0191   .0049  0.0000

          2 HV+LS     .0452   .0525   .0539   .0029  0.0000  0.0000
                      .0155   .0167   .0169   .0040  0.0000  0.0000

          3 N         .0466   .0423   .0204   .0073  0.0000  0.0000     TOTALS    0.0000  0.0000  0.0000   .8236   .9927  1.0000
                      .0158   .0151   .0106   .0064  0.0000  0.0000     LANE 1    0.0000  0.0000  0.0000   .0285   .0064  0.0000

          3 HV        .0073   .0029  0.0000  0.0000  0.0000  0.0000     TOTALS     .9271   .9402   .9708   .1662   .0073  0.0000
                      .0064   .0040  0.0000  0.0000  0.0000  0.0000     LANE 2     .0195   .0177   .0126   .0279   .0064  0.0000

          3 LS        .0160   .0131   .0087   .0029  0.0000  0.0000     TOTALS     .0729   .0598   .0292   .0102  0.0000  0.0000
                      .0094   .0085   .0070   .0040  0.0000  0.0000     LANE 3     .0195   .0177   .0126   .0075  0.0000  0.0000

          3 HV+LS     .0029   .0015  0.0000  0.0000  0.0000  0.0000
                      .0040   .0029  0.0000  0.0000  0.0000  0.0000
```

```
                          DEMOCRACY BLVD.
                          GORE SIGN (AFTER)
                          8/21/72
                          0930-1430

EXIT TRAFFIC                                        TRAP
     562                    1         2         3          4          5          6

               1 N       0.0000    0.0000    0.0000     .7135      .7965      .8221
                         0.0000    0.0000    0.0000     .0374      .0339      .0316

               1 HV      0.0000    0.0000    0.0000     .0231      .0178      .0214
                         0.0000    0.0000    0.0000     .0124      .0109      .0120

               1 LS      0.0000    0.0000    0.0000     .1335      .1601      .1495
                         0.0000    0.0000    0.0000     .0281      .0303      .0295

               1 HV+LS   0.0000    0.0000    0.0000     .0125      .0125      .0071
                         0.0000    0.0000    0.0000     .0092      .0092      .0070

               2 N        .6263     .5192     .6281     .0516      .0089     0.0000
                          .0400     .0401     .0409     .0183      .0078     0.0000

               2 HV       .1246     .1210     .0979     .0053     0.0000     0.0000
                          .0273     .0270     .0246     .0060     0.0000     0.0000

               2 LS       .1299     .1477     .1975     .0480      .0089     0.0000
                          .0278     .0293     .0329     .0177      .0078     0.0000

               2 HV+LS    .0587     .0605     .0534     .0018     0.0000     0.0000
                          .0194     .0197     .0186     .0035     0.0000     0.0000

               3 N        .0356     .0231     .0107     .0036      .0036     0.0000
                          .0153     .0124     .0085     .0049      .0049     0.0000

               3 HV       .0089     .0053    0.0000    0.0000      .0018     0.0000
                          .0078     .0060    0.0000    0.0000      .0035     0.0000

               3 LS       .0142     .0178     .0107     .0071     0.0000     0.0000
                          .0098     .0109     .0085     .0070     0.0000     0.0000

               3 HV+LS    .0019     .0053     .0018    0.0000     0.0000     0.0000
                          .0035     .0060     .0035    0.0000     0.0000     0.0000
```



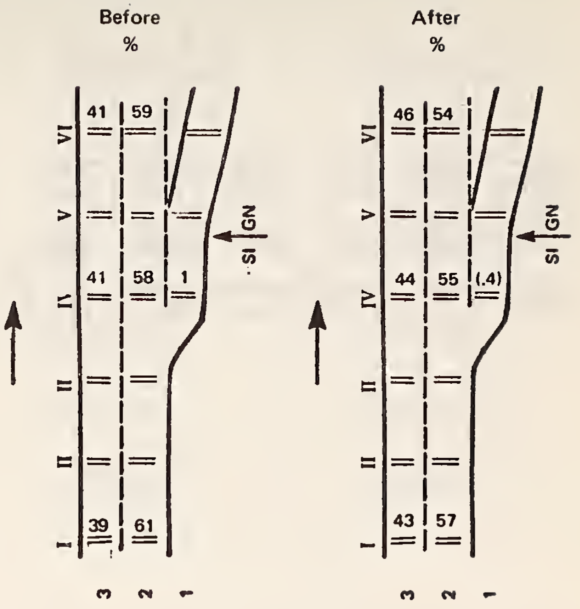


```
TOTALS     0.0000       0.0000     0.0000       .8826       .9769     1.0000
LANE 1     0.0000       0.0000     0.0000       .0266  N.S. .0124     0.0000

TOTALS      .9395        .0494      .9769       .1068       .0178     0.0000
LANE 2      .0197  N.S.  .0183      .0124       .0255  N.S. .0109     0.0000

TOTALS      .0605        .0516      .0231       .0107       .0053     0.0000
LANE 3      .0197  N.S.  .0183      .0124       .0085       .0060     0.0000
```

The significant improvement in lane placement found for exiting traffic on Tuesday is not confirmed by the Monday data. There are no significant differences at Traps 1 and 4. This may be due to the sampling problem in the Before phase data as previously mentioned.

```
                     DEMOCRACY BLVD.
                     GORE SIGN (BEFORE)
                     8/23/71
                     0930-1030

EXIT TRAFFIC                           TRAP
    121                1       2       3       4       5       6

          1 N        0.0000  0.0000  0.0000   .7521   .8182   .7686
                     0.0000  0.0000  0.0000   .0769   .0687   .0751

          1 HV       0.0000  0.0000  0.0000   .0248   .0248   .0331
                     0.0000  0.0000  0.0000   .0277   .0277   .0319

          1 LS       0.0000  0.0000  0.0000   .1322   .1488   .1818
                     0.0000  0.0000  0.0000   .0604   .0634   .0687

          1 HV+LS    0.0000  0.0000  0.0000   .0083   .0083   .0165
                     0.0000  0.0000  0.0000   .0161   .0161   .0227

          2 N         .6529   .6529   .6446   .0413  0.0000  0.0000
                      .0848   .0848   .0853   .0355  0.0000  0.0000

          2 HV        .0826   .0826   .0909  0.0000  0.0000  0.0000
                      .0491   .0491   .0512  0.0000  0.0000  0.0000

          2 LS        .1570   .1488   .2149   .0413  0.0000  0.0000
                      .0648   .0634   .0732   .0355  0.0000  0.0000

          2 HV+LS     .0413   .0826   .0331  0.0000  0.0000  0.0000
                      .0355   .0491   .0319  0.0000  0.0000  0.0000

          3 N         .0413   .0331   .0165  0.0000  0.0000  0.0000     TOTALS    0.0000  0.0000  0.0000   .9174  1.0000  1.0000
                      .0355   .0319   .0227  0.0000  0.0000  0.0000     LANE 1    0.0000  0.0000  0.0000   .0491  0.0000  0.0000

          3 HV       0.0000  0.0000  0.0000  0.0000  0.0000  0.0000     TOTALS     .9339   .9669   .9835   .0826  0.0000  0.0000
                     0.0000  0.0000  0.0000  0.0000  0.0000  0.0000     LANE 2     .0443   .0319   .0227   .0491  0.0000  0.0000

          3 LS        .0248  0.0000  0.0000  0.0000  0.0000  0.0000     TOTALS     .0661   .0331   .0165  0.0000  0.0000  0.0000
                      .0277  0.0000  0.0000  0.0000  0.0000  0.0000     LANE 3     .0443   .0319   .0227  0.0000  0.0000  0.0000

          3 HV+LS    0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
                     0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
```

```
                        DEMOCRACY BLVD.
                        GORE SIGN (AFTER)
                        9/22/72
                        0930-1430

THRU TRAFFIC                                   TRAP
    5514                  1        2        3        4        5        6

              1 N       0.0000   0.0000   0.0000    .0027    .0011   0.0000
                        0.0000   0.0000   0.0000    .0014    .0009   0.0000

              1 HV      0.0000   0.0000   0.0000    .0002   0.0000   0.0000
                        0.0000   0.0000   0.0000    .0004   0.0000   0.0000

              1 LS      0.0000   0.0000   0.0000    .0003    .0005   0.0000
                        0.0000   0.0000   0.0000    .0003    .0006   0.0000

              1 HV+LS   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

              2 N        .4449    .4358    .4309    .4387    .4334    .4244
                         .0131    .0131    .0131    .0131    .0131    .0130

              2 HV       .0396    .0395    .0388    .0323    .0296    .0290
                         .0051    .0051    .0051    0047     .0045    .0044

              2 LS       .0749    .0738    .0662    .0724    .0762    .0805
                         .0059    .0059    .0065    .0068    .0070    .0072

              2 HV+LS    .0123    .0116    .0114    .0100    .0098    .0102
                         .0029    .0028    .0028    .0026    .0026    .0026

              3 N        .3192    .3270    .3384    .3322    .3371    .3390
                         .0123    .0124    .0125    .0124    .0125    .0125

              3 HV       .0557    .0550    .0575    .0540    .0540    .0582
                         .0061    .0060    .0061    .0060    .0060    .0062

              3 LS       .0399    .0401    .0419    .0424    .0419    .0430
                         .0052    .0052    .0053    .0053    .0053    .0054

              3 HV+LS    .0145    .0172    .0149    .0141    .0163    .0158
                         .0032    .0034    .0032    .0031    .0033    .0033
```



```
TOTALS    0.0000    0.0000   0.0000     .0038 |   .0016   0.0000
LANE 1    0.0000    0.0000   0.0000     .0016 ↓   .0011   0.0000

TOTALS     .5707 |   .5608    .5473     .5533 |   .5490    .5441
LANE 2     .0131 ↓   .0131    .0131     .0131 ↓   .0131    .0131

TOTALS     .4293 ↑   .4392    .4527     .4429 ↑   .4494    .4559
LANE 3     .0131 |   .0131    .0131     .0131 |   .0131    .0131
```

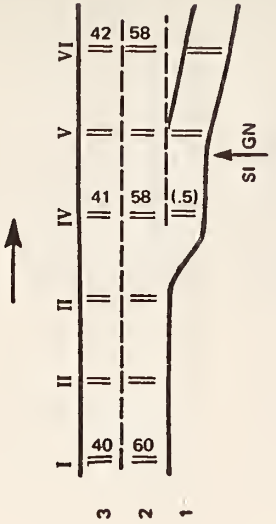
Significantly fewer false moves into the deceleration lane were made by through vehicles under the diagrammatic signing condition (Lane 1, Trap 4). Through traffic was also more evenly distributed across the two through lanes in the After phase (significant differences in Lanes 2 and 3 at Traps 1 and 4). An interpretation is that fewer through vehicles used the right-most lane at this exit because they were more confident in their decision not to exit at this ramp when the diagrammatics were present. However, before this shift can be accepted as favorable, it must be shown that there were no negative effects at the second gore.

```
                    DEMOCRACY BLVD.
                    GCRE SIGN (BEFORE)
                    8/24/71
                    0930-1430

THRU TRAFFIC                             TRAP
   4715                 1        2        3        4        5        6

          1 N        0.0000   0.0000   0.0000    .0066    .0019   0.0000
                     0.0000   0.0000   0.0000    .0023    .0012   0.0000

          1 HV       0.0000   0.0000   0.0000   0.0000    .0002   0.0000
                     0.0000   0.0000   0.0000   0.0000    .0004   0.0000

          1 LS       0.0000   0.0000   0.0000    .0015    .0002   0.0000
                     0.0000   0.0000   0.0000    .0011    .0004   0.0000

          1 HV+LS    0.0000   0.0000   0.0000    .0002   0.0000   0.0000
                     0.0000   0.0000   0.0000    .0004   0.0000   0.0000

          2 N         .4479    .4505    .4494    .4481    .4458    .4333
                      .0142    .0142    .0142    .0142    .0142    .0141

          2 HV        .0414    .0399    .0386    .0282    .0278    .0356
                      .0057    .0056    .0055    .0047    .0047    .0053

          2 LS        .1020    .0990    .0899    .0950    .1029    .0997
                      .0086    .0085    .0082    .0084    .0087    .0086

          2 HV+LS     .0185    .0159    .0146    .0134    .0134    .0199
                      .0038    .0036    .0034    .0033    .0033    .0040

          3 N         .3020    .3065    .3141    .3154    .3137    .3092     TOTALS    0.0000   0.0000   0.0000    .0083    .0023   0.0000
                      .0131    .0132    .0132    .0133    .0132    .0132     LANE 1    0.0000   0.0000   0.0000    .0026    .0014   0.0000

          3 HV        .0367    .0335    .0346    .0344    .0344    .0456     TOTALS     .6098    .6053    .5926    .5847    .5898    .5885
                      .0054    .0051    .0052    .0052    .0052    .0060     LANE 2     .0139    .0140    .0140    .0141    .0140    .0140

          3 LS        .0409    .0456    .0477    .0473    .0479    .0454     TCTALS     .3902    .3947    .4074    .4070    .4078    .4115
                      .0057    .0060    .0061    .0061    .0061    .0059     LANE 3     .0139    .0140    .0140    .0140    .0140    .0140

          3 HV+LS     .0106    .0091    .0110    .0100    .0119    .0112
                      .0029    .0027    .0030    .0028    .0031    .0030
```

```
                                  DEMOCRACY BLVD.
                                  GORE SIGN (AFTER)
                                  8/21/72
                                  0530-1430

THRU TRAFFIC                                     TRAP
   5090                     1        2        3        4        5        6

           1 N          0.0000   0.0000   0.0000    .0037    .0024   0.0000
                        0.0000   0.0000   0.0000    .0017    .0013   0.0000

           1 HV         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

           1 LS         0.0000   0.0000   0.0000    .0004    .0004   0.0000
                        0.0000   0.0000   0.0000    .0005    .0005   0.0000

           1 HV+LS      0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

           2 N           .4424    .4424    .4360    .4271    .4350    .4242
                         .0136    .0136    .0136    .0136    .0136    .0136

           2 HV          .0373    .0418    .0403    .0322    .0275    .0305
                         .0052    .0055    .0054    .0049    .0045    .0047

           2 LS          .0949    .0929    .0892    .1053    .0951    .0941
                         .0081    .0080    .0078    .0084    .0091    .0080

           2 HV+LS       .0141    .0130    .0102    .0098    .0030    .0104
                         .0032    .0031    .0028    .0027    .0026    .0028

           3 N           .3051    .3020    .3161    .3157    .3220    .3238
                         .0126    .0126    .0128    .0128    .0128    .0129

           3 HV          .0507    .0491    .0517    .0475    .0479    .0511
                         .0060    .0059    .0061    .0058    .0059    .0060

           3 LS          .0393    .0434    .0432    .0448    .0460    .0519
                         .0053    .0056    .0056    .0057    .0058    .0061

           3 HV+LS       .0155    .0153    .0143    .0134    .0138    .0141
                         .0034    .0034    .0033    .0032    .0032    .0032
```

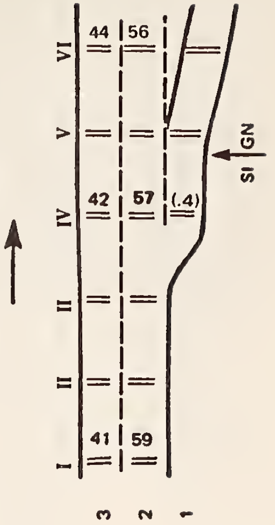
Before

%



After

%



```
TOTALS     0.0000        0.0000   0.0000      .0041        .0028   0.0000
LANE 1     0.0000        0.0000   0.0000      .0018 N.S.   .0014   0.0000

TOTALS      .5894         .5902    .5747      .5745        .5675    .5591
LANE 2      .0135 N.S.    .0135    .0136      .0136 N.S.   .0136    .0136

TOTALS      .4106         .4098    .4253      .4214        .4297    .4409
LANE 3      .0135 N.S.    .0135    .0136      .0136 N.S.   .0136    .0136
```

The significant differences in lane placement seen in the Tuesday paired data are not seen in the Monday data. Placement at Traps 1 and 4 is not significantly different. This may be due to the sampling problem in the Before phase on Monday previously mentioned.

```
                    DEMOCRACY BLVD.
                    GORE SIGN (BEFORE)
                    8/23/71
                    0930-1030

THRU TRAFFIC                           TRAP
   1015                  1       2       3       4       5       6

          1 N         0.0000  0.0000  0.0000   .0049  0.0000  0.0000
                      0.0000  0.0000  0.0000   .0043  0.0000  0.0000

          1 HV        0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
                      0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

          1 LS        0.0000  0.0000  0.0000  0.0000   .0030  0.0000
                      0.0000  0.0000  0.0000  0.0000   .0033  0.0000

          1 HV+LS     0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
                      0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

          2 N          .4788   .4729   .4621   .4709   .4621   .4532
                       .0307   .0307   .0307   .0307   .0307   .0306

          2 HV         .0335   .0374   .0345   .0207   .0187   .0256
                       .0111   .0117   .0112   .0088   .0083   .0097

          2 LS         .0818   .0749   .0768   .0867   .0975   .0906
                       .0169   .0162   .0164   .0173   .0183   .0177

          2 HV+LS      .0108   .0128   .0099   .0059   .0089   .0099
                       .0064   .0069   .0061   .0047   .0058   .0061

          3 N          .3182   .3232   .3379   .3360   .3340   .3399     TOTALS    0.0000  0.0000  0.0000   .0049   .0030  0.0000
                       .0287   .0288   .0291   .0291   .0290   .0291     LANE 1    0.0000  0.0000  0.0000   .0043   .0033  0.0000

          3 HV         .0355   .0374   .0394   .0335   .0384   .0365     TOTALS     .6049   .5980   .5833   .5842   .5872   .5793
                       .0114   .0117   .0120   .0111   .0118   .0115     LANE 2     .0301   .0302   .0303   .0303   .0303   .0304

          3 LS         .0286   .0305   .0266   .0305   .0256   .0335     TOTALS     .3951   .4020   .4167   .4108   .4099   .4207
                       .0102   .0106   .0099   .0106   .0097   .0111     LANE 3     .0301   .0302   .0303   .0303   .0303   .0304

          3 HV+LS      .0128   .0108   .0128   .0108   .0118   .0108
                       .0069   .0064   .0069   .0064   .0066   .0064
```

To summarize, about ten percent of the northbound I-70S traffic exits at the first Democracy Boulevard ramp. Mean vehicular speeds by lane over the 1500-foot tapeswitch array deployed around the approach to this interchange remained about the same in the After phase compared to those found in the Before phase.

One of the paired Before phase data collection days represented the first fifth of the usual five-hour sampling interval. Few significant differences were found when this day was compared to the equivalent day in the After phase.

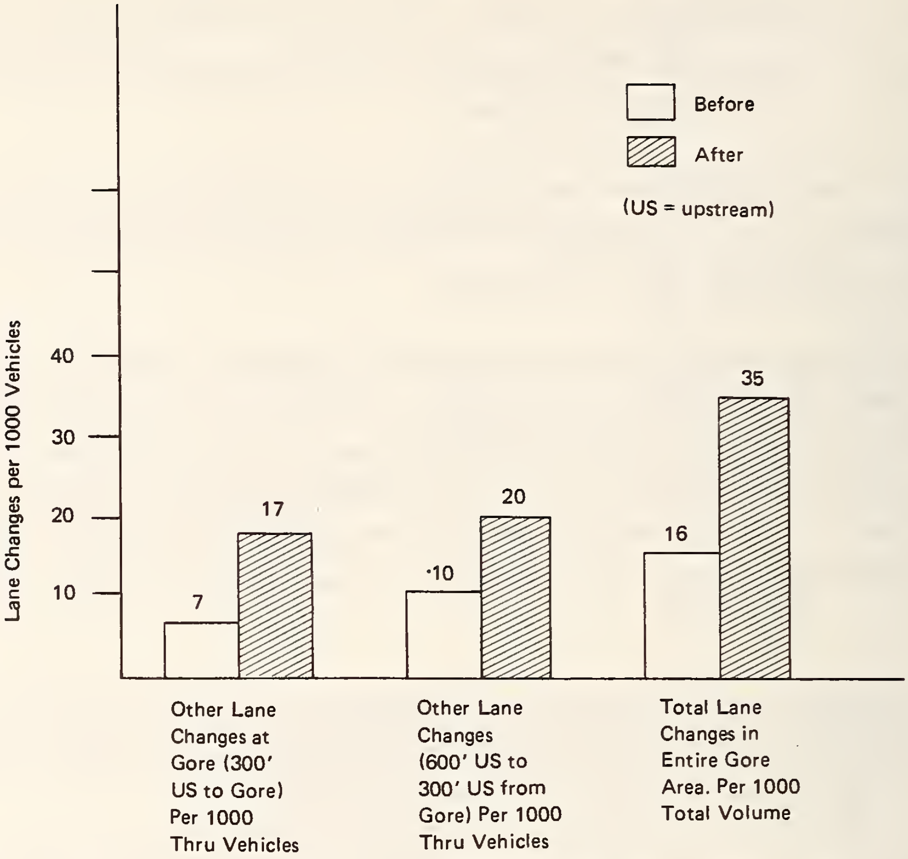
For the other pair of Before/After days, hazardous maneuvers alone and in combination with other criteria (speed differences and headway violations) were generally significantly reduced under the diagrammatic signing condition for autos, for the population as a whole, and for vehicles coded as local by license plate. Lane placement data for exiting and through traffic also indicated a significant improvement under the diagrammatic condition. Differences were small, however, and not nearly as dramatic as those found at the major fork interchange (17 North).

The data suggest a small improvement in performance at the first exit for this cloverleaf interchange when it was signed with diagrammatics. The diagrammatics showed a simple curving arrow for this exit and an implied crossover for the second exit.

Attention is now turned to the data collected with time-lapse photography at the second exit and at the advance and exit direction locations.

Second Gore (Democracy Boulevard West). At this location, only three films were taken per phase. The filming times were 0930, 1100, and 1400. Exiting traffic here made up about 13 percent of total volume in 1971 and 17 percent in 1972. There was a very low incidence of gore weaves, at most one or two per thousand exiting volume. There were no exit returns in either the Before or After phase.

Other lane changes per thousand *through vehicles* showed an increase in the After phase. The area extending from 600 feet upstream to the physical gore yielded an average of about 37 lane changes in the After phase as compared to 17 in the Before phase. In the Before phase, seven of these lane changes occurred in the area from 300 feet upstream to the gore, and ten occurred between 600 feet and 300 feet from the gore. In the After phase, 17 occurred in the area closest to the gore and 20 occurred in the 600 feet to 300 feet (upstream [US] from the gore) zone.



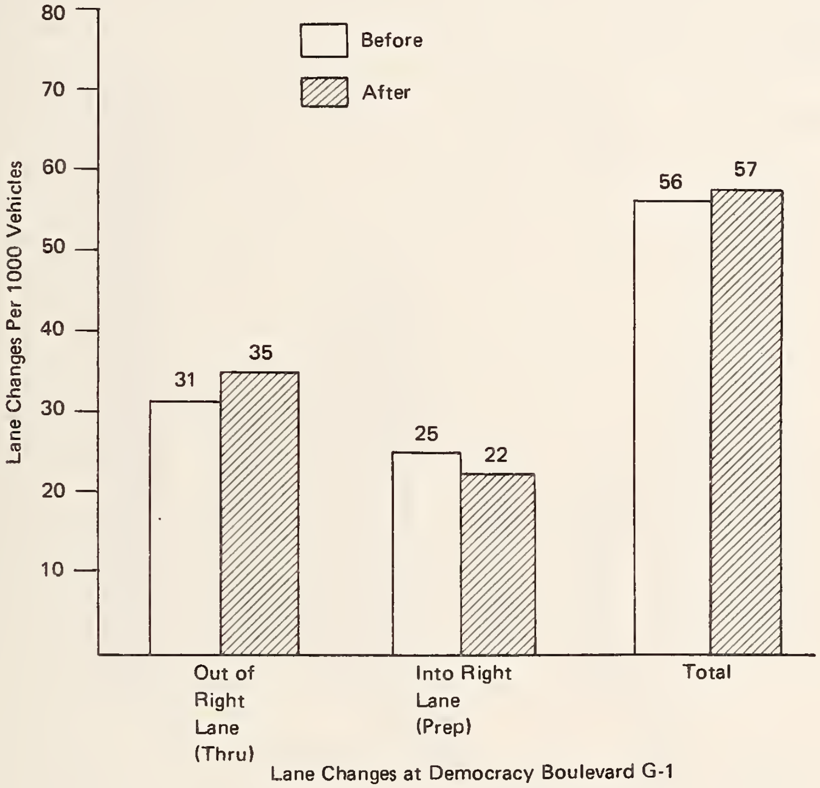
Lane Changes at Democracy West Gore

Total lane changes in the entire area (600 feet upstream to the gore) averaged 35 per thousand *total volume* in the After phase as compared to 16 per thousand in the Before phase. The test for differences between proportions yields a z score of 3.49, a significant difference at the .01 level.

In summary, there was more lane changing in the After phase but no difference was found in hazardous maneuvers at the second gore. The incidence of these maneuvers, however, was so low that the measure has little value. The fact that there was no large increase in erratic maneuvers for exiting vehicles at this gore indicates that the improvement in lane placement for through traffic at the first gore did not have a disbeneficial effect on traffic behavior at the second gore.

Exit Direction (G-1) Sign. This sign is located about one-fourth mile upstream from the first gore. The sign change was rather dramatic. A small conventional sign was replaced by a much larger diagrammatic with both exits shown. The second exit was depicted as an "implied crossover" (see pictures in Chapter III).

Because I-70S is only two lanes wide on the approach to the Democracy Boulevard interchange, all lane changes are classified as either preparatory or through. The zone scored from the film extended from the sign to 600 feet downstream. The figure shows proportions of preparatory and through maneuvers counted in the Before and After phases.



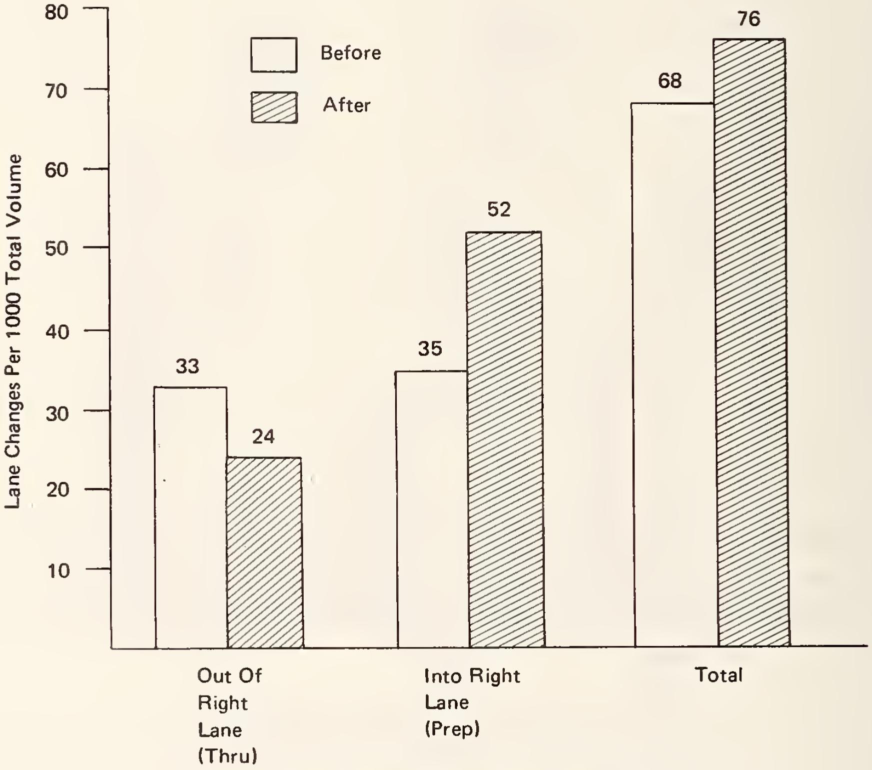
Lane Changes at Democracy Boulevard G-1

Lane changes at G-1 showed little difference in either preparatory or through maneuvers. Through changes (out of the right lane) averaged 31 per thousand total volume in the Before Phase and 35 per thousand in the After Phase. The proportions are not significantly different by the z test.

Preparatory maneuvers into the right lane were also insignificantly different. The same is true of total changes (sum of both preparatory and through maneuvers).

Thus, the change in signs had no significant impact on motorist behavior as measured by the incidence of preparatory and through maneuvers.

Advance (G-2) sign. This sign is located within one-fourth mile of the gore at Interchange 17 North. The sign was not changed to a diagrammatic, and no modifications were made to it. Preparatory and through maneuvers scored from the film in a zone extending from the sign to 750 feet downstream from it are shown in the figure.



Lane Changes at Democracy Boulevard G-2

Through lane changes average 33 per thousand total volume in the Before phase and 24 per thousand in the After phase. The difference is not significant (z = 1.92).

Preparatory maneuvers rose in the After phase from 35 to 52 per thousand total volume. The increase is significant at the .01 level (z=2.80).

With a decrease in through maneuvers and an increase in preparatory maneuvers, total maneuvers showed only a slight difference between the Before and After phases with an average of 68 per thousand Before and 76 per thousand After. The proportions are not significantly different.

Summary. At the first gore, hazardous maneuvers and lane placement data for exiting and through traffic suggest a small improvement under the diagrammatic signing condition. However, no significant improvement in performance at the second gore was found. Given the reduction in hazardous maneuvers at the first gore, an increase in preparatory and/or through maneuvers upstream from the sign might be expected. Such a shift was not found at the exit direction location, however. There was no significant difference in preparatory or through maneuvers in the Before and After phases. The location where a shift was found was at the G-2 sign where preparatory maneuvers increased significantly in the After phase. However, *no signing change was made at this location.* A likely explanation for the increase in preparatory maneuvers is the change in traffic distribution under the diagrammatic signing condition at Interchange 17 North, located a short distance before the advance sign for Democracy Boulevard. It will be remembered that in the After phase at 17 North, traffic exiting onto the two lanes which become I-70S was more evenly distributed than in the Before phase in which the majority of vehicles were located in the right-most of the two lanes. If some of the vehicles shifted into the left lane at 17 North in the After phase were motorists intending to exit at Democracy Boulevard (and roughly 20 percent of the traffic does exit at one of these two exits), such vehicles would then have to move to the right. If this hypothesis is true (and it could only be verified by studying longer segments of roadway), then what we are seeing is the impact of changes in traffic behavior at one interchange affecting behavior at a second interchange.

With regard to the relative effectiveness of diagrammatic and conventional signs at this interchange, it can be said that the diagrammatics did not have a negative impact on traffic behavior and appear to have had a marginal benefit at the first gore.

Interchange 18 East

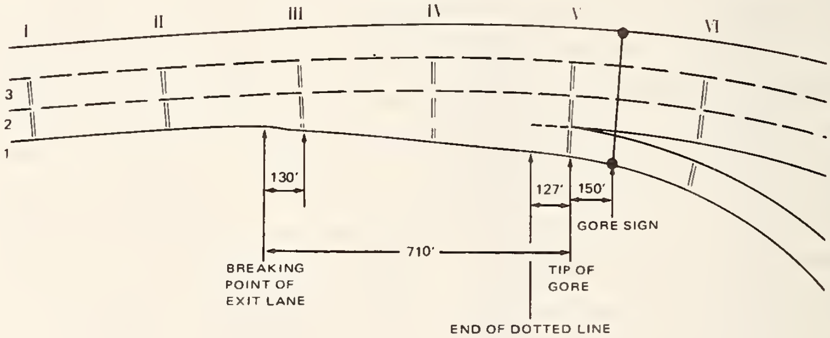
The approach here is to a simple diamond interchange with a right-hand off ramp. The exit ramp includes a deceleration lane. Guidance signing consists of shoulder mounted advance and exit direction signs and an overhead sign at the gore.

The approach involves small vertical rises and drops. Between the exit direction sign and the gore itself, there is a vertical drop and then a rising approach to the gore.

All sign locations were instrumented with the TES. The data collected at the gore are presented first, followed by results at the exit direction and gore sign locations.

Gore. Because of input limitations to the Traffic Evaluator System, the left lane was not instrumented. The location of the tapeswitches in the 1500-foot array is shown diagrammatically below. The deceleration lane and exit ramp are labeled Lane 1. Through traffic lanes are Lanes 2 and 3.

Exit 18E Gore



The average hourly percentage of traffic striking each trap in each lane was similar in the Before and After phases. Sixteen to 17 percent of the total traffic measured exited at the gore. The percentage of autos and nonautos exiting was about one percent higher in the Before phase. The range in average hourly percentages of vehicles recorded in each lane at the sixth trap collected over the four data collection days (two in the Before and two in the After phase) was:

		Total	Auto	Nonauto
Lane 1	(Exiting)	16-17	17-18	5-7
Lane 2	(Through)	29-30	25-27	65-67
Lane 3	(Through)	53-55	55-58	26-30

The majority of the traffic was automobile traffic. While 17 to 18 percent of the auto traffic exited, only five to seven percent of the nonauto traffic exited. In the through lanes, the majority of autos were found in Lane 3 while nonautos primarily used the shoulder-most through lane (Lane 2).

Mean absolute speed by lane and trap are shown for the Wednesday paired data collection days in the Before and After phases. Vehicles were manually coded on this day and thus mean absolute speeds for subpopulations of vehicles coded as local and nonlocal are also shown. The summed N (sample size) values for local and nonlocal vehicles does not equal the total N because the manual coding was interrupted by 15 minute rest breaks throughout the day. Values similar to those seen in the columns labeled TOTAL were found on the other two data collection days (in which manual coding was not done).

Mean absolute speeds are quite similar in the Before and After phases and for the local and nonlocal subpopulations. Mean speeds in Lane 3 are about 5 mph faster than mean speeds in Lane 2. There is a reduction in mean speed as the gore is approached which may be attributable to the vertical rise or to an effect of the gore itself or both. Speeds in the exit ramp and deceleration lane are slower than those in the through traffic lane as would be expected.

Tables showing the proportions of vehicles meeting the criteria defined in Chapter V are presented next, followed by lane placement data for exiting and through traffic. Data within each table (or each set of Before and After tables for the lane placement data) are paired by weekday. The first table shows data collected on September 8, 1971 and September 6, 1972, both Wednesday. Each table is accompanied by annotations and, for lane placement data, illustrations which highlight features of the table.

```
                                                            INTERCHANGE 18 EAST
                                                            GORE SIGN (BEFORE)
                                                            9/8/71
                                                            0930-1430

                           TRAP 1                 TRAP 2                 TRAP 3                 TRAP 4                 TRAP 5                 TRAP 6
                                    NON-                   NON-                   NON-                   NON-                   NON-                   NON-
ABSOLUTE SPEED       TOTAL  LOCAL  LOCAL    TOTAL  LOCAL  LOCAL    TOTAL  LOCAL  LOCAL    TOTAL  LOCAL  LOCAL    TOTAL  LOCAL  LOCAL    TOTAL  LOCAL  LOCAL

 LANE 1
   N                     0      0      0        0      0      0       71     26      4      842    310     51      763    290     43      767    296     41
   MEAN               0.00   0.00   0.00     0.00   0.00   0.00    55.68  53.99  60.16    52.86  52.73  53.91    46.17  45.81  47.64    40.63  40.42  41.40
   STAND DEV          0.00   0.00   0.00     0.00   0.00   0.00     7.56   9.80   2.78     5.94   6.31   5.38     5.74   6.02   5.43     5.75   5.95   5.50
   SKEWNESS           0.00   0.00   0.00     0.00   0.00   0.00    -2.33  -2.43  -1.12     -.19   -.46    .22     -.28   -.33    .37     -.09    .04   -.25
   KURTOSIS           0.00   0.00   0.00     0.00   0.00   0.00    13.39  10.63   2.30     5.98   8.03   3.91     4.73   5.20   3.94     4.10   3.76   3.19

 LANE 2
   N                  1936    744    112     1938    740    112     1934    747    110     1207    480     63     1288    488     71     1318    499     73
   MEAN              58.10  57.72  59.55    57.84  57.36  59.27    56.92  56.59  58.00    56.41  55.91  57.42    55.47  54.97  56.22    54.59  54.21  54.84
   STAND DEV          6.71   7.00   6.27     6.42   6.75   6.07     5.99   6.03   5.53     6.24   6.00   5.36     6.30   6.36   5.37     6.22   6.30   5.50
   SKEWNESS           -.50   -.72   -.45     -.63   -.97   -.31     -.18   -.21    .13     -.27   -.16    .16     -.04   -.36    .09     -.07   -.39    .03
   KURTOSIS           5.22   6.03   3.88     6.21   7.58   4.13     4.44   4.01   3.27     4.99   3.25   2.90     4.04   4.56   2.95     3.77   4.43   2.67

 LANE 3
   N                  2469    923     57     2467    927     57     2401    895     55     2357    878     55     2355    890     55     2321    873     55
   MEAN              64.04  63.91  63.51    64.20  64.06  63.74    62.95  62.84  62.41    61.67  61.55  60.93    60.32  60.24  59.77    59.19  59.11  59.49
   STAND DEV          5.17   5.37   5.05     5.14   5.24   5.22     5.10   5.16   4.88     5.20   5.43   5.10     5.13   5.23   5.31     5.17   5.35   5.44
   SKEWNESS            .01    .14    .24      .01    .18    .54      .02    .18    .44      .01   -.18    .52      .09    .12    .45     -.19   -.55    .48
   KURTOSIS           5.02   3.59   2.96     5.03   3.57   3.06     5.07   3.63   2.86     5.22   6.36   2.72     4.14   4.14   3.16     6.43   9.49   2.86
```

```
                                                            INTERCHANGE 18 EAST
                                                            GORE SIGN (AFTER)
                                                            9/6/72
                                                            0930-1430

                           TRAP 1                 TRAP 2                 TRAP 3                 TRAP 4                 TRAP 5                 TRAP 6
                                    NON-                   NON-                   NON-                   NON-                   NON-                   NON-
ABSOLUTE SPEED       TOTAL  LOCAL  LOCAL    TOTAL  LOCAL  LOCAL    TOTAL  LOCAL  LOCAL    TOTAL  LOCAL  LOCAL    TOTAL  LOCAL  LOCAL    TOTAL  LOCAL  LOCAL

 LANE 1
   N                     0      0      0        0      0      0       65     33      3      922    448     54      808    391     41      807    395     40
   MEAN               0.00   0.00   0.00     0.00   0.00   0.00    59.96  60.08  60.03    54.40  54.24  55.52    46.81  46.95  46.82    39.61  39.67  39.15
   STAND DEV          0.00   0.00   0.00     0.00   0.00   0.00     6.06   6.59   5.17     5.76   5.84   5.94     5.51   5.64   5.45     5.65   6.03   4.37
   SKEWNESS           0.00   0.00   0.00     0.00   0.00   0.00      .51    .46    .71      .09    .09   -.59     -.07    .08   -.62     -.18   -.31   -.02
   KURTOSIS           0.00   0.00   0.00     0.00   0.00   0.00     3.16   2.75   1.50     3.47   3.39   3.22     3.28   3.47   2.96     4.67   5.49   2.27

 LANE 2
   N                  2084    958    150     2097    970    149     2089    964    149     1275    572    101     1385    623    113     1419    633    116
   MEAN              57.84  57.82  57.81    58.79  58.61  58.70    58.50  58.25  58.72    58.64  58.29  58.31    57.18  56.72  57.05    55.90  55.54  55.53
   STAND DEV          6.42   6.59   6.07     6.37   6.52   6.00     6.10   6.24   6.08     6.23   6.37   6.12     6.37   6.67   6.16     6.34   6.47   6.56
   SKEWNESS           -.16   -.22    .08     -.01   -.05    .03      .12    .04    .03      .34    .17    .27      .15    .06   -.28     -.17    .11   -.94
   KURTOSIS           4.15   3.91   2.97     4.23   3.77   3.00     4.03   3.50   3.46     4.43   3.33   4.79     4.61   3.65   6.74     4.82   3.55   8.92

 LANE 3
   N                  2873   1282    227     2060   1270    228     2003   1243    225     2760   1220    222     2764   1226    223     2731   1212    221
   MEAN              63.55  63.44  63.99    63.97  63.80  64.55    63.46  63.31  63.99    62.88  62.78  63.29    61.64  61.53  61.84    60.15  60.00  60.55
   STAND DEV          5.02   5.24   5.28     4.98   5.18   5.26     4.92   5.11   5.24     4.96   5.12   5.36     4.99   5.10   5.57     4.94   5.04   5.32
   SKEWNESS            .32    .34    .13      .25    .29    .03      .25    .32    .05      .23    .29   -.03      .14    .19   -.15      .21    .21   -.04
   KURTOSIS           4.13   4.43   3.29     3.62   3.84   3.06     3.59   3.86   2.87     3.56   3.82   2.97     3.52   3.82   2.92     4.06   4.08   2.91
```

INTERCHANGE 18 EAST
GORE SIGN (BEFORE)
9/8/71
0930-1430

INTERCHANGE 18 EAST
GORE SIGN (AFTER)
9/6/72
0930-1430

	AUTOS 4034	AUTOS 4486	NONAUTOS 372	NONAUTOS 471	ALL 4406	ALL 4957
1. SPEED DIFFERENCE	.18914 .01209	.18992 .01148 N.S.	.29839 .04650	.41401 .04448 ↑	.19837 .01177	.21122 .01136 N.S.
2. HEADWAY VIOLATION	.07362 .00806	.08159 .00801 N.S.	.03763 .01934	.01911 .01236 N.S.	.07059 .00756	.07565 .00736 N.S.
3. HAZARDOUS MANUEVERS	.04883 .00665	.03388 .00529 ↓	.13172 .03437	.06369 .02205 ↓	.05583 .00678	.03672 .00524 ↓
4. 1 + 2	.04090 .00611	.04169 .00585 N.S.	.03495 .01866	.04459 .01864 N.S.	.04040 .00581	.04196 .00558 N.S.
5. 2 + 3	.00645 .00247	.00201 .00131 ↓	.00806 .00909	.00212 .00416 N.S.	.00658 .00239	.00202 .00125 ↓
6. 1 + 3	.02529 .00484	.02452 .00453 N.S.	.11559 .03249	.05308 .02025 ↓	.03291 .00527	.02723 .00453 N.S.
7. 1 + 2 + 3	.00446 .00206	.00201 .00131 ↓	.01075 .01048	.00849 .00829 N.S.	.00499 .00208	.00262 .00142 N.S.
8. NORMAL	.61130 .01504	.52439 .01417 N.S.	.36290 .04886	.39490 .04415 N.S.	.59033 .01452	.60258 .01362 N.S.
9. DBL LANE CHANGES	.02157 .00448	.01204 .00319 ↓	.01344 .01170	.00637 .00718 N.S.	.02088 .00422	.01150 .00297 ↓

The main difference in the After data is the significant reduction in hazardous maneuvers alone and in combination with headway violations. The reduction is particularly noticeable in the nonauto subpopulation where the percentage of vehicles performing these maneuvers dropped from 13% to 6%. (Hazardous maneuvers are maneuvers which are defined for both exiting and through traffic. Examples are weaves across the gore, entries into the deceleration lane followed by a return to the through traffic lanes, and entering the deceleration lane from a position in Lane 3 in the vicinity of Traps 4 and 5. The contribution of particular types of maneuvers to the overall hazardous maneuver value in these tables can be identified from the lane placement tables which follow.)

	INTERCHANGE 18 EAST GORE SIGN (BEFORE) 9/9/71 0930-1430	INTERCHANGE 18 EAST GORE SIGN (AFTER) 9/7/72 0930-1430

	AUTOS 3453	AUTOS 4381		NONAUTOS 352	NONAUTOS 449		ALL 3805	ALL 4830	
1. SPEED DIFFERENCE	.19577 .01323	.18512 .01150	N.S.	.34375 .04962	.35189 .04417	N.S.	.20946 .01293	.20062 .01129	N.S.
2. HEADWAY VIOLATION	.06516 .00823	.07555 .00783	N.S.	.02557 .01649	.02895 .01551	N.S.	.06150 .00763	.07122 .00725	N.S.
3. HAZARDOUS MANUEVERS	.05039 .00730	.03880 .00572	↓	.14205 .03647	.07127 .02380	↓	.05887 .00748	.04182 .00565	↓
4. 1 + 2	.03852 .00642	.03949 .00577	N.S.	.01136 .01107	.05122 .02039	↑	.03601 .00592	.04058 .00556	N.S.
5. 2 + 3	.00319 .00188	.00365 .00179	N.S.	.00852 .00960	.00223 .00436	N.S.	.00368 .00192	.00352 .00167	N.S.
6. 1 + 3	.02809 .00551	.02305 .00444	N.S.	.13352 .03553	.08686 .02605	↓	.03784 .00606	.02899 .00473	↓
7. 1 + 2 + 3	.00405 .00212	.00571 .00223	N.S.	.00568 .00785	.00891 .00869	N.S.	.00420 .00206	.00600 .00218	N.S.
8. NORMAL	.61483 .01623	.62862 .01431	N.S.	.32955 .04911	.39866 .04529	↑	.58844 .01564	.60725 .01377	N.S.
9. DBL LANE CHANGES	.01448 .00398	.01324 .00338	N.S.	.00284 .00556	0.00000 0.00000		.01340 .00365	.01201 .00307	N.S.

The Thursday data show fewer significant differences than the Wednesday data. However, the drop in hazardous maneuvers is also found in the Thursday data and is again very pronounced for nonautos.

		INTERCHANGE 18 EAST GORE SIGN (BEFORE) 9/8/71 0930-1430			INTERCHANGE 18 EAST GORE SIGN (AFTER) 9/6/72 0930-1430					
		LOCAL	LOCAL		FOREIGN	FOREIGN		ALL	ALL	
		1668	2240		169	377		1837	2617	
1.	SPEED DIFFERENCE	.20324 .01931	.20937 .01685	N.S.	.18935 .05907	.23607 .04287	N.S.	.20196 .01836	.21322 .01569	N.S.
2.	HEADWAY VIOLATION	.06475 .01181	.07545 .01094	N.S.	.04734 .03202	.05040 .02208	N.S.	.06315 .01112	.07184 .00989	N.S.
3.	HAZARDOUS MANUEVERS	.05935 .01134	.03750 .00787	↓	.12426 .04974	.04244 .02035	↓	.06532 .01130	.03821 .00735	↓
4.	1 + 2	.04556 .01001	.05089 .00910	N.S.	.02959 .02555	.02653 .01622	N.S.	.04409 .00939	.04738 .00814	N.S.
5.	2 + 3	.00719 .00406	.00268 .00214	N.S.	.00592 .01156	.00265 .00519	N.S.	.00708 .00383	.00267 .00198	↓
6.	1 + 3	.03297 .00857	.03259 .00735	N.S.	.01775 .01991	.01326 .01155	N.S.	.03157 .00800	.02981 .00652	N.S.
7.	1 + 2 + 3	.00719 .00406	.00268 .00214	N.S.	0.00000 0.00000	0.00000 0.00000		.00653 .00368	.00229 .00183	↓
8.	NORMAL	.57974 .02369	.58884 .02038	N.S.	.58580 .07427	.62865 .04877	N.S.	.58029 .02257	.59457 .01881	N.S.
9.	DBL LANE CHANGES	.02398 .00734	.01161 .00444	↓	.02367 .02292	.01061 .01034	N.S.	.02395 .00699	.01146 .00408	↓

The local and foreign subpopulations are similar to the data for the population as a whole collected on the same day (two tables back) in terms of particular significant differences found. It is important to note, however, that the reduction in hazardous maneuvers is particularly pronounced for the foreign vehicle subpopulation (vehicles with plates other than Maryland, Virginia or the District of Columbia). The incidence of hazardous maneuvers for this subpopulation has been reduced to one-third that seen in the Before phase. This reduction is even greater than the sizable drop for the nonauto subpopulation.

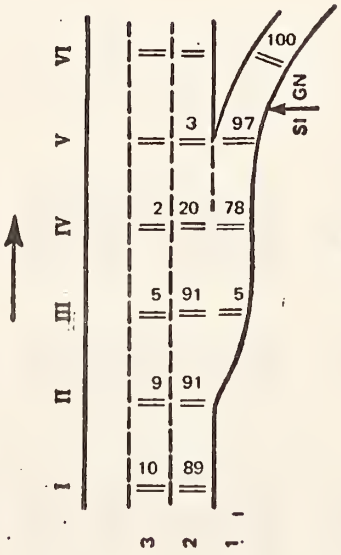
The conclusion from the three tables which have been presented is that the diagrammatic signs are associated with a significant reduction in hazardous maneuvers at the gore. The reduction is particularly pronounced for nonauto traffic (to one-half the level found in the Before phase) and for vehicles coded as foreign (to one-third the level found in the Before phase). Consistent changes were not found for the other measures.

Attention is now turned to the placement of the exiting and through vehicle populations in the three instrumented lanes as the vehicles negotiate the gore.

INTERCHANGE 18 EAST
GORE SIGN (AFTER)
9/6/72
0930-1430

EXIT TRAFFIC 807	TRAP 1	2	3	4	5	6
1 N	0.0000 0.0000	0.0000 0.0000	.0545 .0157	.6543 .0328	.7831 .0284	.7943 .0279
1 HV	0.0000 0.0000	0.0000 0.0000	.0037 .0042	.0347 .0126	.0322 .0122	.0347 .0126
1 LS	0.0000 0.0000	0.0000 0.0000	.0074 .0059	.1574 .0251	.1524 .0248	.1537 .0249
1 HV+LS	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.0198 .0096	.0235 .0105	.0173 .0090
2 N	.7175 .0311	.7100 .0313	.6406 .0331	.0793 .0186	.0012 .0024	0.0000 0.0000
2 HV	.0582 .0162	.0607 .0165	.0632 .0168	.0012 .0024	0.0000 0.0000	0.0000 0.0000
2 LS	.1314 .0233	.1549 .0250	.1871 .0269	.0458 .0144	.0037 .0042	0.0000 0.0000
2 HV+LS	.0285 .0115	.0285 .0115	.0235 .0105	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
3 N	.0471 .0146	.0273 .0112	.0099 .0068	.0037 .0042	.0037 .0042	0.0000 0.0000
3 HV	.0074 .0059	.0050 .0048	.0025 .0034	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
3 LS	.0099 .0068	.0124 .0076	.0074 .0059	.0025 .0034	0.0000 0.0000	0.0000 0.0000
3 HV+LS	0.0000 0.0000	.0012 .0024	0.0000 0.0000	.0012 .0024	0.0000 0.0000	0.0000 0.0000

Before
%



After
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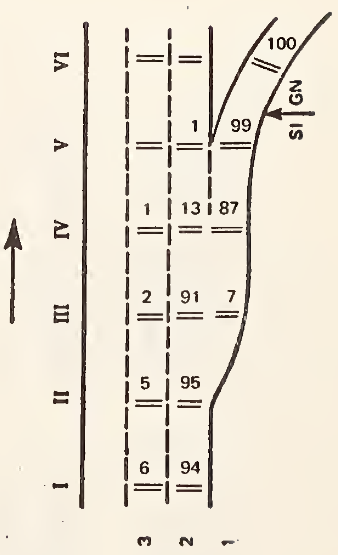

TOTALS LANE 1	0.0000 0.0000	0.0000 0.0000	.0657 .0171	.8662 ↑ .0235	.9913 .0064	1.0000 0.0000
TOTALS LANE 2	.9356 ↑ .0169	.9542 .0144	.9145 .0193	.1264 ↓ .0229	.0050 .0048	0.0000 0.0000
TOTALS LANE 3	.0644 ↓ .0169	.0458 .0144	.0198 .0096	.0074 ↓ .0059	.0037 .0042	0.0000 0.0000

Lane placement for exiting vehicles was significantly better in the After phase. (The data for the Before phase used in preparing the illustration is on the following page.) In the After phase, fewer exiting vehicles entered the array in Lane 3 and their movement out of Lanes 2 and 3 and into the deceleration lane occurred more upstream from the gore. (Significant differences are only indicated at Traps 1 and 4.) These data indicate that a major contribution to the reduction in hazardous maneuvers presented in earlier tables was due to improved performance in the After phase by exiting traffic.

```
                     INTERCHANGE 18 EAST
                     GORE SIGN (BEFORE)
                     9/8/71
                     0930-1430

EXIT TRAFFIC                        TRAP
    767                  1      2      3      4      5      6

           1 N         .0013  .0013  .0365  .5945  .7784  .8253
                       .0026  .0026  .0133  .0347  .0294  .0269

           1 HV       0.0000 0.0000  .0039  .0222  .0235  .0235
                      0.0000 0.0000  .0044  .0104  .0107  .0107

           1 LS       0.0000 0.0000  .0065  .1538  .1578  .1382
                      0.0000 0.0000  .0057  .0255  .0258  .0244

           1 HV+LS    0.0000 0.0000  .0013  .0065  .0104  .0130
                      0.0000 0.0000  .0026  .0057  .0072  .0080

           2 N         .6780  .7014  .6701  .1213  .0091 0.0000
                       .0331  .0324  .0333  .0231  .0067 0.0000

           2 HV        .0508  .0443  .0495  .0013 0.0000 0.0000
                       .0155  .0146  .0154  .0026 0.0000 0.0000

           2 LS        .1317  .1421  .1695  .0717  .0169 0.0000
                       .0239  .0247  .0266  .0183  .0091 0.0000

           2 HV+LS     .0339  .0248  .0169  .0065 0.0000 0.0000
                       .0128  .0110  .0091  .0057 0.0000 0.0000

           3 N         .0730  .0522  .0287  .0169  .0026 0.0000      TOTALS      .0013  .0013  .0482  .7771  .9700 1.0000
                       .0184  .0157  .0118  .0091  .0036 0.0000      LANE 1      .0026  .0026  .0152  .0295  .0121 0.0000

           3 HV        .0091  .0091  .0052  .0026  .0013 0.0000      TOTALS      .8944  .9126  .9061  .2008  .0261 0.0000
                       .0067  .0067  .0051  .0036  .0026 0.0000      LANE 2      .0218  .0200  .0206  .0284  .0113 0.0000

           3 LS        .0209  .0235  .0104  .0026 0.0000 0.0000      TOTALS      .1043  .0860  .0456  .0222  .0039 0.0000
                       .0101  .0107  .0072  .0036 0.0000 0.0000      LANE 3      .0216  .0198  .0148  .0104  .0044 0.0000

           3 HV+LS     .0013  .0013  .0013 0.0000 0.0000 0.0000
                       .0026  .0026  .0026 0.0000 0.0000 0.0000
```

```
                         INTERCHANGE 18 EAST
                         GORE SIGN (AFTER)
                         9/7/72
                         0930-1430

EXIT TRAFFIC                               TRAP
   758                      1        2        3        4        5        6

             1 N          .0013    .0013    .0462    .6108    .7691    .7850
                          .0026    .0026    .0149    .0347    .0300    .0292

             1 HV        0.0000   0.0000    .0013    .0277    .0290    .0277
                         0.0000   0.0000    .0026    .0117    .0120    .0117

             1 LS        0.0000   0.0000    .0119    .1728    .1675    .1662
                         0.0000   0.0000    .0077    .0269    .0266    .0265

             1 HV+LS     0.0000   0.0000    .0026    .0198    .0198    .0211
                         0.0000   0.0000    .0037    .0099    .0099    .0102

             2 N          .6741    .6557    .6201    .0844    .0053   0.0000
                          .0334    .0338    .0346    .0198    .0052   0.0000

             2 HV         .0528    .0528    .0541    .0092    .0013   0.0000
                          .0159    .0159    .0161    .0068    .0026   0.0000

             2 LS         .1544    .2018    .2045    .0554    .0040   0.0000
                          .0257    .0286    .0287    .0163    .0045   0.0000

             2 HV+LS      .0330    .0277    .0277    .0026    .0013   0.0000
                          .0127    .0117    .0117    .0037    .0026   0.0000

             3 N          .0580    .0422    .0198    .0145    .0013   0.0000
                          .0166    .0143    .0099    .0085    .0026   0.0000

             3 HV         .0119    .0079    .0066    .0026   0.0000   0.0000
                          .0077    .0063    .0058    .0037   0.0000   0.0000

             3 LS         .0092    .0053    .0053   0.0000   0.0000   0.0000
                          .0068    .0052    .0052   0.0000   0.0000   0.0000

             3 HV+LS      .0053    .0053   0.0000   0.0000    .0013   0.0000
                          .0052    .0052   0.0000   0.0000    .0026   0.0000
```

Before
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After
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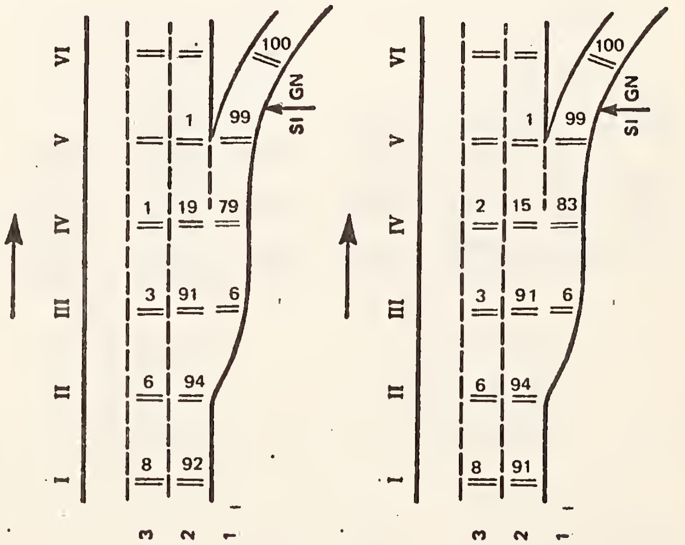


```
TOTALS      .0013    .0013    .0620    .8311      .9855   1.0000
LANE 1      .0026    .0026    .0172    .0267      .0085   0.0000

TOTALS      .9142    .9380    .9063    .1517  |   .0119   0.0000
LANE 2      .0199    .0172    .0207    .0255  ↓   .0077   0.0000

TOTALS      .0844    .0607    .0317    .0172      .0026   0.0000
LANE 3      .0198    .0170    .0125    .0092      .0037   0.0000
```

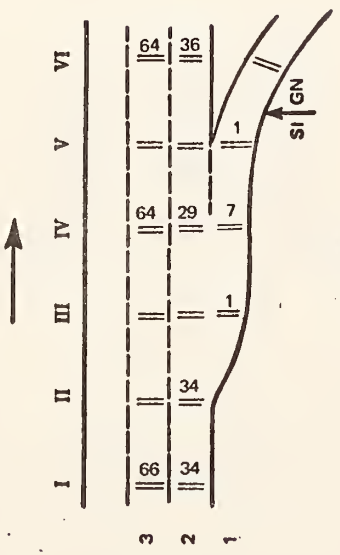
The same pattern of changes seen in the Wednesday data occur in the Thursday data. Exiting traffic in the After phase left Lanes 2 and 3 more promptly and there were fewer last minute maneuvers into the deceleration lane and exit ramp. All but one of the proportions at Traps 1 and 4 are not significantly different, however.

```
                        INTERCHANGE 18 EAST
                        GORE SIGN (BEFORE)
                        9/9/71
                        0930-1430

EXIT TRAFFIC                              TRAP
    662                    1        2        3        4        5        6

           1 N          0.0000   0.0000    .0498    .5483    .7644    .7961
                        0.0000   0.0000    .0166    .0379    .0323    .0307

           1 HV         0.0000   0.0000    .0060    .0287    .0242    .0227
                        0.0000   0.0000    .0059    .0127    .0117    .0113

           1 LS         0.0000   0.0000    .0030    .1934    .1752    .1571
                        0.0000   0.0000    .0042    .0301    .0290    .0277

           1 HV+LS      0.0000   0.0000    .0015    .0211    .0227    .0242
                        0.0000   0.0000    .0030    .0110    .0113    .0117

           2 N           .6873    .6828    .6329    .1163    .0045   0.0000
                         .0353    .0355    .0367    .0244    .0051   0.0000

           2 HV          .0453    .0514    .0589    .0060   0.0000   0.0000
                         .0158    .0168    .0179    .0059   0.0000   0.0000

           2 LS          .1601    .1782    .1964    .0695    .0050   0.0000
                         .0279    .0292    .0303    .0194    .0059   0.0000

           2 HV+LS       .0272    .0242    .0257    .0030   0.0000   0.0000
                         .0124    .0117    .0120    .0042   0.0000   0.0000

           3 N           .0544    .0393    .0227    .0091    .0015   0.0000      TOTALS   0.0000   0.0000    .0604    .7915    .9864   1.0000
                         .0173    .0148    .0113    .0072    .0030   0.0000      LANE 1   0.0000   0.0000    .0182    .0309    .0088   0.0000

           3 HV          .0030    .0060   0.0000   0.0000   0.0000   0.0000      TOTALS    .9199    .9366    .9139    .1949    .0106   0.0000
                         .0042    .0059   0.0000   0.0000   0.0000   0.0000      LANE 2    .0207    .0186    .0214    .0302    .0078   0.0000

           3 LS          .0181    .0151    .0030    .0045    .0015   0.0000      TOTALS    .0801    .0634    .0257    .0136    .0030   0.0000
                         .0102    .0093    .0042    .0051    .0030   0.0000      LANE 3    .0207    .0186    .0120    .0088    .0042   0.0000

           3 HV+LS       .0045    .0070   0.0000   0.0000   0.0000   0.0000
                         .0051    .0042   0.0000   0.0000   0.0000   0.0000
```

INTERCHANGE 18 EAST
GORE SIGN (AFTER)
9/6/72
0930-1430

THRU TRAFFIC 4150	TRAP 1	2	3	4	5	6
1 N	0.0000 0.0000	0.0000 0.0000	.0022 .0014	.0460 .0064	.0010 .0009	0.0000 0.0000
1 HV	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.0002 .0005	.0002 .0005	0.0000 0.0000
1 LS	0.0000 0.0000	0.0000 0.0000	.0002 .0005	.0072 .0026	.0007 .0008	0.0000 0.0000
1 HV+LS	0.0000 0.0000	0.0000 0.0000	.0005 .0007	.0002 .0005	0.0000 0.0000	0.0000 0.0000
2 N	.2424 .0130	.2400 .0130	.2552 .0133	.2214 .0126	.2586 .0133	.2658 .0134
2 HV	.0065 .0024	.0060 .0024	.0096 .0030	.0070 .0025	.0058 .0023	.0070 .0025
2 LS	.0675 .0076	.0696 .0077	.0576 .0071	.0508 .0067	.0653 .0075	.0655 .0075
2 HV+LS	.0039 .0019	.0041 .0019	.0031 .0017	.0034 .0018	.0031 .0017	.0036 .0018
3 N	.5492 .0151	.5496 .0151	.5455 .0151	.5330 .0152	.5282 .0152	.5195 .0152
3 HV	.0366 .0057	.0335 .0055	.0325 .0054	.0366 .0057	.0383 .0058	.0412 .0060
3 LS	.0865 .0086	.0899 .0087	.0839 .0084	.0836 .0084	.0875 .0086	.0853 .0085
3 HV+LS	.0075 .0026	.0072 .0026	.0096 .0030	.0104 .0031	.0113 .0032	.0120 .0033
TOTALS LANE 1	0.0000 0.0000	0.0000 0.0000	.0029 .0016	.0537 ↓ .0069	.0019 .0013	0.0000 0.0000
TOTALS LANE 2	.3202 ↓ .0142	.3198 .0142	.3255 .0143	.2827 .0137	.3328 .0143	.3419 .0144
TOTALS LANE 3	.6798 ↑ .0142	.6802 .0142	.6716 .0143	.6636 .0144	.6653 .0144	.6581 .0144

Before
%



After
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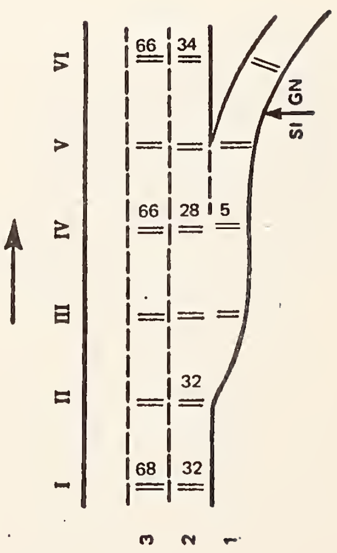


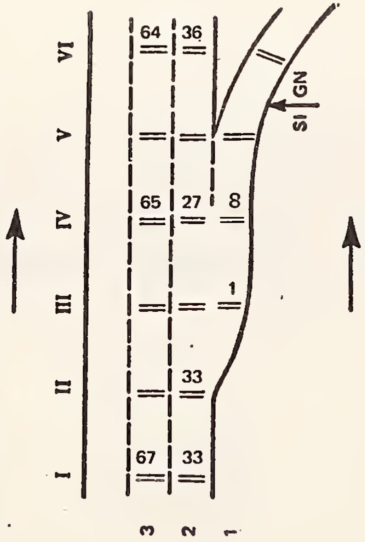
For the through traffic subpopulation, the Wednesday data show some improvement in the After phase. Entries into the deceleration lane are reduced. A slightly higher proportion of through traffic is located in Lane 3. (Significant changes at Traps 1 and 4 only are indicated.)

```
                        INTERCHANGE 18 EAST
                        GCRE SIGN (BEFORE)
                        9/8/71
                        0930-1430

THRU TRAFFIC                                  TRAP
   3639                   1        2        3        4        5        6

          1 N         0.0000   0.0000    .0069    .0599    .0044   0.0000
                      0.0000   0.0000    .0027    .0077    .0021   0.0000

          1 HV        0.0000   0.0000   0.0000    .0005    .0003   0.0000
                      0.0000   0.0000   0.0000    .0008    .0005   0.0000

          1 LS        0.0000   0.0000    .0025    .0069    .0005   0.0000
                      0.0000   0.0000    .0016    .0027    .0008   0.0000

          1 HV+LS     0.0000   0.0000   0.0000    .0063   0.0000   0.0000
                      0.0000   0.0000   0.0000    .0065   0.0000   0.0000

          2 N          .2638    .2715    .2773    .2369    .2784    .2866
                       .0143    .0144    .0145    .0138    .0146    .0147

          2 HV         .0129    .0107    .0107    .0047    .0058    .0060
                       .0037    .0033    .0033    .0022    .0025    .0025

          2 LS         .0627    .0555    .0497    .0453    .0618    .0651
                       .0079    .0074    .0071    .0068    .0078    .0080

          2 HV+LS      .0041    .0025    .0027    .0025    .0025    .0044
                       .0021    .0016    .0017    .0016    .0016    .0021

          3 N          .5361    .5403    .5356    .5260    .5268    .5133      TCTALS   0.0000   0.0000    .0053    .0676    .0052   0.0000
                       .0162    .0162    .0162    .0162    .0162    .0162      LANE 1   0.0000   0.0000    .0031    .0082    .0023   0.0000

          3 HV         .0311    .0294    .0275    .0261    .0297    .0368      TCTALS    .3435    .3402    .3405    .2894    .3484    .3622
                       .0056    .0055    .0053    .0052    .0055    .0061      LANE 2    .0154    .0154    .0154    .0147    .0155    .0156

          3 LS         .0827    .0833    .0794    .0852    .0833    .0800      TCTALS    .6565    .6598    .6502    .6430    .6463    .6378
                       .0089    .0090    .0088    .0091    .0090    .0088      LANE 3    .0154    .0154    .0155    .0156    .0155    .0156

          3 HV+LS      .0066    .0069    .0077    .0058    .0066    .0077
                       .0026    .0027    .0028    .0025    .0026    .0028
```

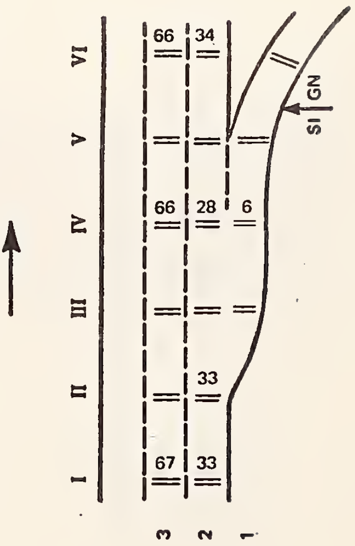
INTERCHANGE 18 EAST
GORF SIGN (AFTER)
9/7/72
0930-1430

THRU TRAFFIC 4072	TRAP 1	2	3	4	5	6
1 N	0.0000 0.0000	0.0000 0.0000	.0017 .0013	.0511 .0068	.0015 .0012	0.0000 0.0000
1 HV	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.0015 .0012	0.0000 0.0000	0.0000 0.0000
1 LS	0.0000 0.0000	0.0000 0.0000	.0002 .0005	.0091 .0029	.0007 .0008	0.0000 0.0000
1 HV+LS	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	.0005 .0007	0.0000 0.0000	0.0000 0.0000
2 N	.2529 .0134	.2500 .0133	.2625 .0135	.2186 .0127	.2642 .0135	.2657 .0136
2 HV	.0076 .0027	.0083 .0028	.0103 .0031	.0064 .0024	.0059 .0024	.0061 .0024
2 LS	.0646 .0075	.0653 .0076	.0555 .0070	.0508 .0067	.0643 .0075	.0688 .0078
2 HV+LS	.0044 .0020	.0039 .0019	.0034 .0018	.0015 .0012	.0027 .0016	.0034 .0018
3 N	.5479 .0153	.5459 .0153	.5417 .0153	.5390 .0153	.5339 .0153	.5273 .0153
3 HV	.0341 .0056	.0351 .0057	.0371 .0058	.0371 .0058	.0386 .0059	.0400 .0060
3 LS	.0803 .0083	.0830 .0085	.0783 .0083	.0769 .0082	.0761 .0081	.0766 .0082
3 HV+LS	.0081 .0028	.0083 .0028	.0091 .0029	.0076 .0027	.0120 .0033	.0120 .0033

Before
%



After
%



TOTALS LANE 1	0.0000 0.0000	0.0000 0.0000	.0020 .0014	.0621 .0074	.0022 .0014	0.0000 0.0000
TOTALS LANE 2	.3296 .0144	.3276 .0144	.3318 .0145	.2773 .0137	.3372 .0145	.3441 .0146
TOTALS LANE 3	.6704 .0144	.6724 .0144	.6663 .0145	.6606 .0145	.6606 .0145	.6559 .0146

On Thursday, there is no significant change in the proportion of through vehicles entering the array in Lanes 2 and 3 in the After phase. Entries into the deceleration lane by through vehicles are again significantly reduced.

The reduction in entries into the deceleration lane by through vehicles also contributes to the reduction in hazardous maneuvers seen in the overall tables previously presented.

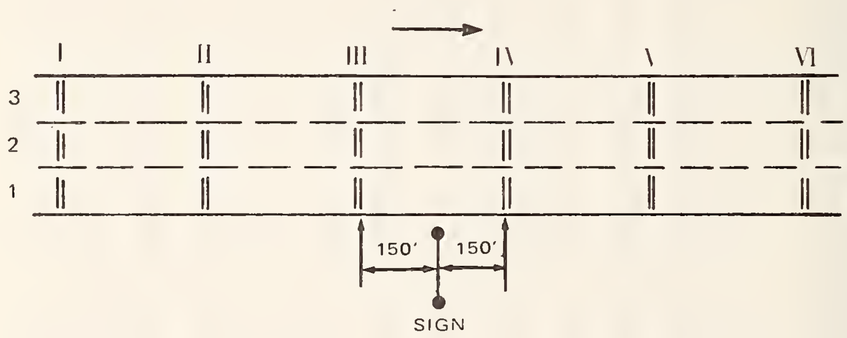
```
                  INTERCHANGE 1B EAST
                  GORE SIGN (BEFORE)
                  9/9/71
                  0930-1430

THRU TRAFFIC                          TRAP
   3143                1       2       3       4       5       6

          1 N       0.0000  0.0000   .0054   .0694   .0013  0.0000
                    0.0000  0.0000   .0026   .0089   .0012  0.0000

          1 HV      0.0000  0.0000   .0003   .0006  0.0000  0.0000
                    0.0000  0.0000   .0005   .0009  0.0000  0.0000

          1 LS      0.0000  0.0000   .0022   .0054  0.0000  0.0000
                    0.0000  0.0000   .0016   .0026  0.0000  0.0000

          1 HV+LS   0.0000  0.0000   .0003   .0003  0.0000  0.0000
                    0.0000  0.0000   .0006   .0006  0.0000  0.0000

          2 N        .2491   .2564   .2692   .2243   .2746   .2867
                     .0151   .0153   .0155   .0146   .0156   .0158

          2 HV       .0083   .0073   .0073   .0029   .0038   .0054
                     .0032   .0030   .0030   .0019   .0022   .0026

          2 LS       .0716   .0636   .0503   .0433   .0565   .0681
                     .0090   .0085   .0076   .0071   .0087   .0088

          2 HV+LS    .0013   .0016   .0025   .0016   .0010   .0013
                     .0012   .0014   .0018   .0014   .0011   .0012

          3 N        .5405   .5485   .5383   .5297   .5304   .5122      TOTALS   0.0000  0.0000   .0083   .0757   .0013  0.0000
                     .0174   .0174   .0174   .0174   .0174   .0175      LANE 1   0.0000  0.0000   .0032   .0092   .0012  0.0000

          3 HV       .0270   .0270   .0283   .0248   .0274   .0321      TOTALS    .3303   .3290   .3293   .2720   .3458   .3614
                     .0057   .0057   .0058   .0054   .0057   .0062      LANE 2    .0164   .0164   .0164   .0156   .0166   .0168

          3 LS       .0955   .0913   .0907   .0910   .0888   .0878      TOTALS    .6697   .6710   .6624   .6522   .6529   .6386
                     .0103   .0101   .0100   .0101   .0099   .0099      LANE 3    .0164   .0164   .0165   .0167   .0166   .0168

          3 HV+LS    .0067   .0041   .0051   .0067   .0064   .0064
                     .0028   .0022   .0025   .0028   .0028   .0028
```

To summarize, about 17 percent of the total traffic studied at the gore of Interchange 18 East exited at the gore. Most of the traffic was auto traffic. Proportionately less of the nonauto traffic studied exited; in the order of six percent. Mean absolute speeds were similar in the Before and After phases for total traffic and for the local and nonlocal vehicle subpopulations.

The change to diagrammatic signs was associated with a significant reduction in hazardous maneuvers. This was particularly pronounced for the nonauto subpopulation (to 1/2 the level in the Before phase) and for the vehicles coded as nonlocal (to 1/3 the level in the Before phase). Lane placement data indicates that exiting traffic was particularly benefited by the signs. The main effect on through traffic was to reduce the incidence of entries into the deceleration lane by such vehicles.

For the other measures used in the study (e.g., speed differences, headway violations), consistent significant differences were not found.

Exit Direction (G-1) Location. All three lanes were instrumented with tapeswitches at this location in the Before and After phases. As at all other advance and exit direction sign locations instrumented, the switches were deployed symmetrically about the sign. The array thus extended from 750 feet upstream of the sign to 750 feet downstream from it.



One of the two days of scheduled data collection in the Before phase was lost because poor weather prevented tapeswitch deployment. The results reported are thus based upon one pair of matched days. These were Tuesday, August 12, 1971 in the Before phase and Tuesday, August 3, 1972 in the After phase. The Before and After data collection days are separated by one year and one week rather than the planned one year separation because poor weather delayed the data collection schedule in the Before phase by one week for several sites. Time constraints prevented a similar compensating adjustment in the After phase.

Comparison of the distribution of vehicles across the three instrumented lanes shows little difference as the vehicles proceeded from Trap 1 to Trap 6. There was little difference between the Before and After phases in the distribution of auto traffic across the three lanes. For the nonautos, some increased usage of Lane 2 in the After phase was found. The percentage of vehicles by type using each lane (derived from mean hourly volume data at each trap) is shown for the sixth trap:

	Total		Auto		Nonauto	
	10/12/71	10/3/72	10/12/71	10/3/72	10/12/71	10/3/72
Lane 1	37.4	36.5	34.5	33.8	70.5	62.7
Lane 2	45.3	44.9	47.2	46.1	23.9	33.5
Lane 3	17.3	18.6	18.3	20.2	5.7	3.8

Because the majority of the traffic was composed of automobiles, the shift in nonauto traffic to Lane 2 had little effect on the distribution of the traffic as a whole.

Mean absolute speed in each lane decreased slightly as the tapeswitch array was traversed from Trap 1 to Trap 6. Absolute mean speeds at Traps 1 and 6 for the traffic as a whole on the Before and After data collection days were:

	Trap 1		Trap 6	
	10/12/71	10/3/72	10/12/71	10/3/72
Lane 1	59.22	56.72	58.50	56.40
Lane 2	65.27	62.22	64.08	61.77
Lane 3	70.29	67.52	69.31	66.78

Mean absolute speed was somewhat higher in the Before phase.

Tables on the following pages show the proportions of vehicles performing preparatory and other defined maneuvers as well as the proportions of vehicles meeting the criteria for speed differences and headway violations.

INTERCHANGE 18 EAST
ADVANCE (G-1) SIGN (BEFORE)
10/12/71
0930-1430

INTERCHANGE 18 EAST
ADVANCE (G-1) SIGN (AFTER)
10/3/72
0930-1430

		AUTOS	AUTOS		NONAUTOS	NONAUTOS		ALL	ALL	
		5010	5035		440	531		5450	5566	
1.	PREP. MANUEVERS	.04411 .00569	.04727 .00586	N.S.	.02273 .01393	.04143 .01695	N.S.	.04239 .00535	.04671 .00554	N.S.
2.	THROUGH MANUEVERS	.02894 .00464	.03734 .00524	↑	.03636 .01749	.03955 .01658	N.S.	.02954 .00450	.03755 .00499	↑
3.	OTHER LANE CHANGES	.02794 .00456	.03932 .00537	↑	.01136 .00990	.02825 .01409	N.S.	.02661 .00427	.03827 .00504	↑
4.	NO LANE CHANGES	.89900 .00834	.87607 .00910	↓	.92955 .02391	.89077 .02653	↓	.90147 .00791	.87747 .00861	↓

		AUTOS	AUTOS		NONAUTOS	NONAUTOS		ALL	ALL	
1.	SPEED DIFFERENCE	.18543 .01076	.06733 .00692	↓	.50227 .04672	.29379 .03874	↓	.21101 .01083	.08893 .00748	↓
2.	HEADWAY VIOLATION	.08483 .00772	.10209 .00836	↑	.02955 .01582	.06591 .02111	↑	.08037 .00722	.09863 .00783	↑
3.	DBL LANE CHANGES	.00120 .00096	.00437 .00182	↑	0.00000 0.00000	0.00000 0.00000		.00110 .00088	.00395 .00165	↑
4.	1 + 2	.03872 .00534	.01827 .00370	↓	.04773 .01992	.03013 .01454	N.S.	.03945 .00517	.01940 .00362	↓
5.	2 + 3	.00040 .00055	.00179 .00117	↑	0.00000 0.00000	0.00000 0.00000		.00037 .00051	.00162 .00106	↑
6.	1 + 3	.00120 .00096	.00159 .00110	N.S.	0.00000 0.00000	0.00000 0.00000		.00110 .00088	.00144 .00100	N.S.
7.	1 + 2 + 3	.00060 .00068	.00040 .00055		.00227 .00445	.00188 .00369	N.S.	.00073 .00072	.00054 .00061	
8.	NORMAL	.68762 .01283	.80417 .01096	↑	.41818 .04609	.60829 .04152	↑	.66587 .01252	.78548 .01078	↑

The reduction in hazardous maneuvers at the gore would suggest a possible increase in preparatory and/or through maneuvers at upstream locations, particularly for the subpopulations showing the major effect at the gore (nonautos and foreign vehicles). At the exit direction sign location, differences in preparatory and through maneuvers are small when the Before and After data are compared. Although both categories increase, the only significant increase is for through maneuvers for the auto subpopulation and for the traffic as a whole. With regard to other criteria (below the dashed line), the most striking change is the reduction in vehicles proceeding through the array at speeds at least 5 mph under the mean speed. The reduction is particularly pronounced for nonautos. Headway violations are slightly increased.

INTERCHANGE 18 EAST
ADVANCE (G-1) SIGN (BEFORE)
10/12/71
0930-1430

INTERCHANGE 18 EAST
ADVANCE (G-1) SIGN (AFTER)
10/3/72
0930-1430

		LOCAL	LOCAL		FOREIGN	FOREIGN		ALL	ALL	
		2715	2939		377	405		3092	3344	
1.	PREP. MANEUVERS	.04236 .00758	.04321 .00735	N.S.	.01857 .01363	.03457 .01779	N.S.	.03946 .00686	.04217 .00681	N.S.
2.	THROUGH MANEUVERS	.03094 .00651	.03743 .00686	N.S.	.03979 .01973	.04198 .01953	N.S.	.03202 .00621	.03798 .00648	N.S.
3.	OTHER LANE CHANGES	.02541 .00592	.03913 .00701	↑	.02653 .01622	.03951 .01897	N.S.	.02555 .00556	.03917 .00658	↑
4.	NO LANE CHANGES	.90129 .01122	.88023 .01174	↓	.91512 .02813	.88395 .03119	N.S.	.90298 .01043	.88068 .01099	↓
1.	SPEED DIFFERENCE	.21510 .01546	.09153 .01043	↓	.18568 .03925	.11605 .03119	↓	.21151 .01439	.09450 .00991	↓
2.	HEADWAY VIOLATION	.08582 .01054	.10310 .01099	↑	.06101 .02416	.05432 .02207	N.S.	.08279 .00971	.09719 .01004	↑
3.	DBL LANE CHANGES	.00147 .00144	.00340 .00211	N.S.	0.00000 0.00000	0.00000 0.00000		.00129 .00127	.00299 .00185	N.S.
4.	1 + 2	.04125 .00748	.02110 .00520	↓	.02387 .01541	.00741 .00835	N.S.	.03913 .00684	.01944 .00468	↓
5.	2 + 3	.00037 .00072	.00170 .00149	N.S.	.00265 .00519	.00247 .00483	N.S.	.00065 .00090	.00179 .00143	N.S.
6.	1 + 3	.00147 .00144	.00102 .00115	N.S.	.00265 .00519	0.00000 0.00000		.00162 .00142	.00090 .00101	N.S.
7.	1 + 2 + 3	.00074 .00102	.00102 .00115	N.S.	0.00000 0.00000	0.00000 0.00000		.00065 .00090	.00090 .00101	N.S.
8.	NORMAL	.65378 .01790	.77714 .01505	↑	.72414 .04512	.81975 .03744	↑	.66235 .01667	.78230 .01399	↑

The reduction in hazardous maneuvers at the gore was pronounced for foreign vehicles. However, no significant increase in preparatory or through maneuvers for this subpopulation is shown at the exit direction sign location.

Both local and foreign vehicles show a significant reduction in the proportions meeting the criterion for speed differences. Headway violations are increased slightly for local vehicles.

To study patterns of movement in the Before and After phases, the total population of vehicles was divided into four subpopulations; vehicles not changing lanes, vehicles moving towards the median, vehicles moving towards the shoulder and vehicles moving in both directions.

The preceding tables show that the great majority of vehicles did not change lanes. The distribution of these vehicles by lane in the Before and After phase (the top number is the proportion of vehicles out of the entire population of vehicles; the bottom number is the 95 percent confidence limit)was:

	10/12/71	10/3/72
Lane 1	.3323 .0125	.3223 .0123
Lane 2	.3994 .0130	.3775 .0127
Lane 3	.1486 .0094	.1597 .0096

The non-lane-changing vehicles are distributed similarly in the Before and After data. The only significant difference is in Lane 2 which contained slightly fewer of these vehicles in the After phase.

The proportion of vehicles moving in both directions was .0062±.0021 in the Before phase and .0214±.0038 in the After phase. The proportions are significantly different.

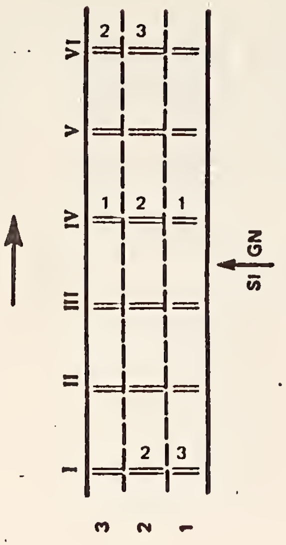
The following tables show the patterns of movement for vehicles shifting lanes to the left and vehicles shifting lanes to the right. The data are very similar in the Before and After phases.

In summary, the most significant change at the exit direction location was the reduction in vehicles traveling through the array at speeds of 5 mph or more below the mean speed for all vehicles.

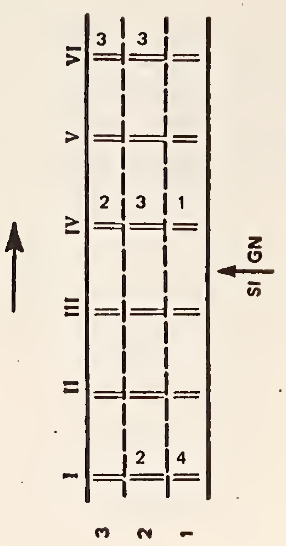
The sizable reductions in hazardous maneuvers found at the gore for the nonauto and foreign vehicle subpopulations suggested that an increase in preparatory and/or through maneuvers might be found at the exit direction and/or advance sign locations for such vehicles. Although preparatory and through maneuvers increased in the After phase, significant increases were found only in through maneuvers for autos and for the population as a whole.

```
                 INTERCHANGE 18 EAST
                 ADVANCE (G-1) SIGN (AFTER)
                 10/3/72
                 0930-1430

5566                    1       2       3       4       5       6

            1 N      .0309   .0261   .0196   .0090   .0031  0.0000
                     .0045   .0042   .0036   .0025   .0014  0.0000

            1 HV     .0025   .0029   .0025   .0011   .0004  0.0000
                     .0013   .0014   .0013   .0009   .0005  0.0000

            1 LS     .0027   .0023   .0023   .0011   .0004  0.0000
                     .0014   .0013   .0013   .0009   .0005  0.0000

            1 HV+LS  .0009   .0005   .0002   .0002  0.0000  0.0000
                     .0008   .0006   .0004   .0004  0.0000  0.0000

VEHICLES    2 N      .0163   .0176   .0178   .0221   .0252   .0253
                     .0033   .0035   .0035   .0039   .0041   .0041

 MOVING     2 HV     .0043   .0045   .0043   .0050   .0038   .0038
                     .0017   .0018   .0017   .0019   .0016   .0016

 TOWARD     2 LS     .0005   .0005   .0011   .0029   .0036   .0041
                     .0006   .0006   .0009   .0014   .0016   .0017

 MEDIAN     2 HV+LS  .0005   .0007   .0009   .0005   .0005   .0005
                     .0006   .0007   .0008   .0006   .0006   .0006

            3 N     0.0000   .0025   .0075   .0135   .0183   .0217   TOTALS    .0370   .0318   .0246   .0113   .0038  0.0000
                    0.0000   .0013   .0023   .0030   .0035   .0038   LANE 1    .0050   .0046   .0041   .0028   .0016  0.0000

            3 HV    0.0000   .0009   .0014   .0022   .0025   .0020   TOTALS    .0217   .0234   .0241   .0305   .0331   .0338
                    0.0000   .0008   .0010   .0012   .0013   .0012   LANE 2    .0038   .0040   .0040   .0045   .0047   .0047

            3 LS    0.0000   .0002   .0011   .0013   .0011   .0013   TOTALS   0.0000   .0036   .0101   .0169   .0219   .0250
                    0.0000   .0004   .0009   .0009   .0009   .0009   LANE 3   0.0000   .0016   .0026   .0034   .0038   .0041

            3 HV+LS 0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
                    0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
```

Before
%



After
%



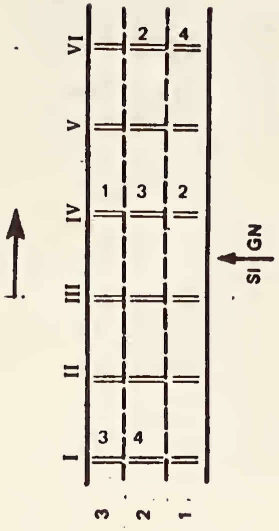
A slightly higher proportion of vehicles shifted lanes to the left in the After phase. Patterns of movement are similar in the two data collection periods.

```
                    INTERCHANGE 18 EAST
                    ADVANCE (G-1) SIGN (BEFORE)
                    10/12/71
                    0930-1430

5450                      1       2       3       4       5       6

          1 N         .0259   .0222   .0169   .0119   .0053  0.0000
                      .0042   .0039   .0034   .0029   .0019  0.0000

          1 HV        .0017   .0020   .0018   .0017   .0006  0.0000
                      .0011   .0012   .0011   .0011   .0006  0.0000

          1 LS        .0015   .0009   .0006   .0004   .0002  0.0000
                      .0010   .0008   .0006   .0005   .0004  0.0000

          1 HV+LS     .0002   .0006   .0004   .0002   .0002  0.0000
                      .0004   .0006   .0005   .0004   .0004  0.0000

VEHICLES  2 N         .0149   .0141   .0143   .0143   .0169   .0198
                      .0032   .0031   .0032   .0032   .0034   .0037

 MOVING   2 HV        .0053   .0050   .0055   .0040   .0042   .0017
                      .0019   .0019   .0020   .0017   .0017   .0011

 TOWARD   2 LS        .0007   .0007   .0013   .0022   .0029   .0048
                      .0007   .0007   .0010   .0012   .0014   .0018

 MEDIAN   2 HV+LS     .0007   .0009   .0006   .0015   .0011   .0009
                      .0007   .0008   .0006   .0010   .0009   .0008

          3 N        0.0000   .0028   .0068   .0105   .0150   .0176  TOTALS    .0292   .0257   .0196   .0141   .0062  0.0000
                     0.0000   .0014   .0022   .0027   .0032   .0035  LANE 1    .0045   .0042   .0037   .0031   .0021  0.0000

          3 HV       0.0000   .0002   .0004   .0011   .0009   .0015  TOTALS    .0217   .0207   .0217   .0220   .0251   .0272
                     0.0000   .0004   .0005   .0009   .0008   .0010  LANE 2    .0039   .0038   .0039   .0039   .0042   .0043

          3 LS       0.0000   .0011   .0020   .0029   .0028   .0039  TOTALS   0.0000   .0044   .0095   .0147   .0194   .0237
                     0.0000   .0009   .0012   .0014   .0014   .0016  LANE 3   0.0000   .0018   .0026   .0032   .0037   .0040

          3 HV+LS    0.0000   .0004   .0004   .0002   .0007   .0007
                     0.0000   .0005   .0005   .0004   .0007   .0007
```

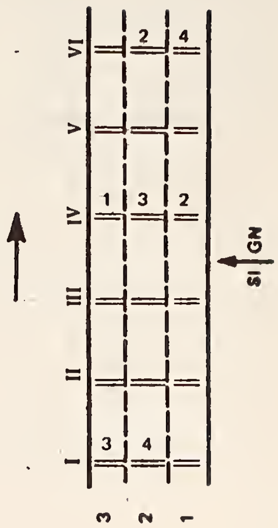
INTERCHANGE 18 EAST
ADVANCE (G-1) SIGN (AFTER)
10/3/72
0930-1430

5566		1	2	3	4	5	6
	1 N	0.0000 0.0000	.0018 .0011	.0088 .0025	.0142 .0031	.0268 .0042	.0332 .0047
	1 HV	0.0000 0.0000	.0004 .0005	.0002 .0004	.0007 .0007	.0020 .0012	.0022 .0012
	1 LS	0.0000 0.0000	0.0000 0.0000	.0004 .0005	.0007 .0007	.0011 .0009	.0016 .0011
	1 HV+LS	0.0000 0.0000	0.0000 0.0000	.0005 .0006	.0005 .0006	.0007 .0007	.0007 .0007
VEHICLES	2 N	.0282 .0043	.0304 .0045	.0278 .0043	.0269 .0043	.0205 .0037	.0203 .0037
MOVING	2 HV	.0032 .0015	.0032 .0015	.0025 .0013	.0029 .0014	.0018 .0011	.0020 .0012
TOWARD	2 LS	.0029 .0014	.0020 .0012	.0018 .0011	.0013 .0009	.0009 .0008	.0004 .0005
SHOULDER	2 HV+LS	.0007 .0007	0.0000 0.0000	.0002 .0004	.0002 .0004	0.0000 0.0000	0.0000 0.0000
	3 N	.0217 .0038	.0205 .0037	.0169 .0034	.0115 .0028	.0059 .0070	0.0000 0.0000
	3 HV	.0023 .0013	.0018 .0011	.0011 .0009	.0013 .0009	.0007 .0007	0.0000 0.0000
	3 LS	.0013 .0009	.0004 .0005	0.0000 0.0000	.0002 .0004	0.0000 0.0000	0.0000 0.0000
	3 HV+LS	0.0000 0.0000	0.0000 0.0000	.0002 .0004	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

Before
%



After
%

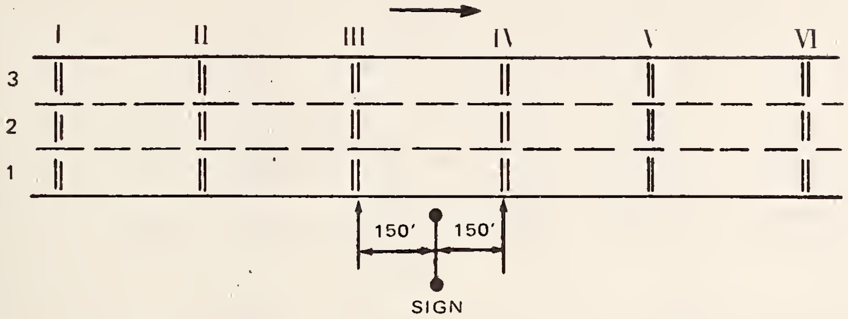


TOTALS LANE 1	0.0000 0.0000	.0022 .0012	.0099 .0026	.0162 .0033	.0305 .0045	.0377 .0050
TOTALS LANE 2	.0350 .0048	.0356 .0049	.0323 .0046	.0313 .0046	.0232 .0040	.0226 .0039
TOTALS LANE 3	.0253 .0041	.0226 .0039	.0181 .0035	.0129 .0030	.0066 .0021	0.0000 0.0000

There is little in the way of significant differences for vehicles moving towards the shoulder in the Before and After phases. About the same proportion of vehicles shifted lanes in this direction in both data collection periods and the patterns of movement are similar.

```
                     INTERCHANGE 18 EAST
                     ADVANCE (G-1) SIGN (BEFORE)
                     10/12/71
                     0930-1430

5450                       1        2        3        4        5        6

           1 N        0.0000    .0046    .0123    .0198    .0272    .0332
                      0.0000    .0018    .0029    .0037    .0043    .0048

           1 HV       0.0000    .0009    .0013    .0026    .0029    .0035
                      0.0000    .0008    .0010    .0013    .0014    .0016

           1 LS       0.0000    .0002    .0002   0.0000    .0006    .0013
                      0.0000    .0004    .0004   0.0000    .0006    .0010

           1 HV+LS    0.0000   0.0000   0.0000   0.0000    .0002    .0007
                      0.0000   0.0000   0.0000   0.0000    .0004    .0007

VEHICLES   2 N         .0277    .0261    .0228    .0211    .0222    .0224
                       .0044    .0042    .0040    .0038    .0039    .0039

 MOVING    2 HV        .0033    .0037    .0035    .0028    .0024    .0013
                       .0015    .0016    .0016    .0014    .0013    .0010

 TOWARD    2 LS        .0042    .0042    .0037    .0031    .0017    .0002
                       .0017    .0017    .0016    .0015    .0011    .0004

SHOULDER   2 HV+LS     .0020    .0005    .0004    .0006    .0002   0.0000
                       .0012    .0006    .0005    .0006    .0004   0.0000

           3 N         .0200    .0185    .0143    .0097    .0042   0.0000   TOTALS      0.0000    .0057    .0138    .0224    .0308    .0387
                       .0037    .0036    .0032    .0026    .0017   0.0000   LANE 1      0.0000    .0020    .0031    .0039    .0046    .0051

           3 HV        .0011    .0015    .0022    .0015    .0006   0.0000   TOTALS       .0372    .0345    .0303    .0275    .0264    .0239
                       .0009    .0010    .0012    .0010    .0006   0.0000   LANE 2       .0050    .0048    .0045    .0043    .0043    .0041

           3 LS        .0040    .0024    .0020    .0015    .0006   0.0000   TOTALS       .0253    .0224    .0185    .0127    .0053   0.0000
                       .0017    .0013    .0012    .0010    .0006   0.0000   LANE 3       .0042    .0039    .0036    .0030    .0019   0.0000

           3 HV+LS     .0002   0.0000   0.0000   0.0000   0.0000   0.0000
                       .0004   0.0000   0.0000   0.0000   0.0000   0.0000
```

Advance (G-2) Location. Instrumentation was the same as that at the exit direction location and is diagrammed below.



Because of bad weather, only one day of data could be collected in the Before phase at the advance sign location. Thus, the results at this site are based upon only one pair of matched days; Wednesday, September 15, 1971 in the Before phase and Wednesday, September 13, 1972 in the After phase.

There was little difference in the percent distribution of vehicles in each lane as vehicles proceeded through the tapeswitch array from Trap 1 to Trap 6. The mean hourly volume of traffic expressed as a percentage by vehicle type is shown below at the sixth trap:

	Total		Auto		Nonauto	
	9/15/71	9/13/72	9/15/71	9/13/72	9/15/71	9/13/72
Lane 1	36.2	33.1	33.2	29.6	72.6	69.5
Lane 2	46.8	47.0	48.6	49.0	25.3	25.9
Lane 3	17.0	19.9	18.2	21.4	2.0	4.7

Usage of each lane by the total traffic population and the auto and nonauto subpopulations was similar to that at the exit direction location. Most of the vehicles studied occupied Lanes 1 and 2. More than two-thirds of the nonauto traffic used the right lane, with about 25 percent in Lane 2. Only two to four percent of the nonauto vehicles were found in Lane 3. On the other hand, nearly one-fifth of the auto traffic used the left lane. The vertical rise on the approach to the advance sign may account for the distribution of vehicles across the lanes.

Absolute mean speed increased slightly as the vehicles traversed the tapeswitch array from Trap 1 to Trap 6. Absolute mean speeds were similar in the Before and After phases and for the local and nonlocal subpopulations. Absolute mean speeds for all vehicles at Traps 1 and 6 in the Before and After phases were:

	Trap 1		Trap 6	
	9/15/71	9/13/72	9/15/71	9/13/72
Lane 1	55.53	54.70	56.02	54.99
Lane 2	61.49	60.75	62.08	61.70
Lane 3	65.69	64.82	66.84	66.05

Tables on the following pages present the proportions of vehicles performing preparatory maneuvers, through maneuvers and other lane changes as well as the proportions meeting the criteria for speed difference, headway violations and classification as normal.

INTERCHANGE 18 EAST
ADVANCE (G-2) SIGN (BEFORE)
9/15/71
0930-1430

INTERCHANGE 18 EAST
ADVANCE (G-2) SIGN (AFTER)
9/13/72
0930-1430

		AUTOS	AUTOS	NONAUTOS	NONAUTOS	ALL	ALL
		4745	5287	391	514	5136	5801
1.	PREP. MANUEVERS	.04278 .00576	.03972 .00526 N.S.	.02813 .01639	.04086 .01711 N.S.	.04167 .00547	.03982 .00503 N.S.
2.	THROUGH MANUEVERS	.04615 .00597	.05239 .00601 N.S.	.03836 .01904	.03891 .01672 N.S.	.04556 .00570	.05120 .00567 N.S.
3.	OTHER LANE CHANGES	.03646 .00533	.03783 .00514 N.S.	.00256 .00501	.00584 .00659 N.S.	.03388 .00495	.03499 .00473 N.S.
4.	NO LANE CHANGES	.87460 .00942	.87006 .00906 N.S.	.93095 .02513	.91440 .02419 N.S.	.87889 .00892	.87399 .00854 N.S.
1.	SPEED DIFFERENCE	.16312 .01051	.11481 .00859 ↓	.65729 .04704	.57198 .04278 ↓	.20074 .01095	.15532 .00932 ↓
2.	HEADWAY VIOLATION	.07545 .00751	.09438 .00788 ↑	.03069 .01710	.02335 .01305 N.S.	.07204 .00707	.08809 .00729 ↑
3.	DBL LANE CHANGES	.00148 .00109	.00189 .00117 N.S.	.00512 .00707	.00195 .00381 N.S.	.00175 .00114	.00190 .00112 N.S.
4.	1 + 2	.03920 .00552	.03083 .00466 ↓	.04092 .01964	.02918 N.S. .01455	.03933 .00532	.03068 .00444 ↓
5.	2 + 3	.00021 .00041	.00095 .00083 N.S.	0.00000 0.00000	0.00000 0.00000	.00019 .00038	.00086 .00076
6.	1 + 3	.00126 .00101	.00113 .00091 N.S.	0.00000 0.00000	0.00000 0.00000	.00117 .00093	.00103 .00083 N.S.,
7.	1 + 2 + 3	.00126 .00101	.00076 .00074	0.00000 0.00000	.00195 .00381	.00117 .00093	.00086 .00076
8.	NORMAL	.71802 .01280	.75525 .01159 ↑	.26598 .04380	.37160 .04178 ↑	.68361 .01272	.72125 .01154 ↑

There are no significant differences in the After phase in the proportions of vehicles performing preparatory maneuvers, through maneuvers, or other lane changes among the auto and nonauto subpopulations nor in the population as a whole. The great majority of the vehicles studied in both phases performed no lane changes at all.

The percentage of vehicles traveling at least 5 mph less than the mean speed for all vehicles was down about 5% in the After phase, a significant difference. The reduction for nonautos was somewhat greater. For autos, the reduction in speed differences was offset by an increase in headway violations but the increase was not as great in magnitude as the decrease in vehicles meeting the speed difference criterion. No significant increase in headway violations was found for nonautos. The proportion of vehicles classified as normal increased in the After study as would be expected, given the change in the proportions of vehicles meeting the other criteria.

INTERCHANGE 18 EAST
ADVANCE (G-2) SIGN (BEFORE)
9/15/71
0930-1430

INTERCHANGE 18 EAST
ADVANCE (G-2) SIGN (AFTER)
9/13/72
0930-1430

		LOCAL	LOCAL		FOREIGN	FOREIGN		ALL	ALL	
		2819	3169		494	460		3313	3629	
1.	PREP. MANUEVERS	.04470 .00763	.03913 .00675	N.S.	.04453 .01819	.04130 .01819	N.S.	.04467 .00703	.03940 .00633	N.S.
2.	THROUGH MANUEVERS	.04612 .00774	.05175 .00771	N.S.	.04049 .01738	.05435 .02072	N.S.	.04528 .00708	.05208 .00723	N.S.
3.	OTHER LANE CHANGES	.03902 .00715	.03566 .00646	N.S.	.02227 .01301	.04348 .01864	N.S.	.03652 .00639	.03665 .00611	N.S.
4.	NO LANE CHANGES	.87017 .01241	.87346 .01158	N.S.	.89271 .02729	.86087 .03163	N.S.	.87353 .01132	.87187 .01087	N.S.
1.	SPEED DIFFERENCE	.19475 .01462	.14894 .01240	↓	.22672 .03692	.17174 .03447	↓	.19952 .01361	.15183 .01168	↓
2.	HEADWAY VIOLATION	.08017 .01002	.09404 .01016	N.S.	.05263 .01969	.08043 .02485	N.S.	.07606 .00903	.09231 .00942	↑
3.	DBL LANE CHANGES	.00177 .00155	.00221 .00163	N.S.	.00405 .00560	.00435 .00601	N.S.	.00211 .00156	.00248 .00162	N.S.
4.	1 + 2	.04221 .00742	.03282 .00620	N.S.	.03036 .01513	.02391 .01396	N.S.	.04045 .00671	.03169 .00570	N.S.
5.	2 + 3	.00035 .00070	.00063 .00087		0.00000 0.00000	0.00000 0.00000		.00030 .00059	.00055 .00076	
6.	1 + 3	.00142 .00139	.00126 .00124	N.S.	.00202 .00396	0.00000 0.00000		.00151 .00132	.00110 .00108	N.S.
7.	1 + 2 + 3	.00142 .00139	.00095 .00107		0.00000 0.00000	0.00000 0.00000		.00121 .00118	.00083 .00094	
8.	NORMAL	.67790 .01725	.71915 .01565	↑	.68421 .04099	.71957 .04105	N.S.	.67884 .01590	.71921 .01462	↑

The data for the local and foreign subpopulations are similar to the nonauto data presented previously although the proportion of vehicles classified as normal is not increased. Data for the local and foreign subpopulations are quite similar.

Attention is next turned to the lane placement data at the advance sign location. As has been shown in the preceding tables, most of the vehicles did not change lanes and differences in the overall proportions were insignificant when Before and After data were compared. The distribution of these vehicles by lane in the Before and After phases (the top number is the proportion; the bottom number is the 95 percent confidence limit) was:

	9/15/71	9/13/72
Lane 1	.3217 .0128	.2932 .0117
Lane 2	.4032 .0134	.3986 .0126
Lane 3	.1275 .0091	.1507 .0092

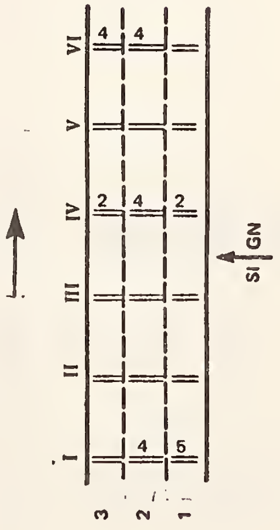
The *location* of the non-lane-changing vehicles was slightly but significantly different in the two phases. In the After phase, a small but significantly higher proportion of these vehicles were located in Lane 3 while a lower proportion were located in Lane 1. The proportions of these vehicles in Lane 2 were essentially the same in both phases.

The proportion of vehicles changing lanes in both directions within the array was .0082 ±.0025 in the Before phase and .0097 ±.0025 in the After phase. These proportions are very small and essentially identical.

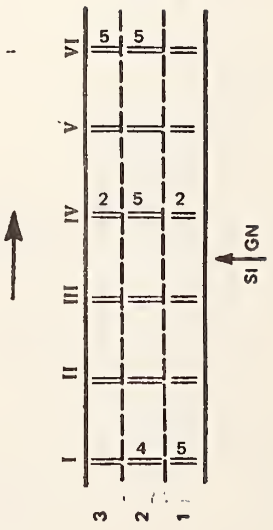
The four tables following present lane placement information for vehicles moving toward the median and toward the shoulder in the Before and After phases. Reference to the tables shows that about nine percent of vehicles shifted toward the shoulder and about five percent of vehicles shifted toward the median in both phases. Patterns of movement are not different in the two phases.

```
                  INTERCHANGE 18 EAST
                  ADVANCE (G-2) SIGN (AFTER)
                  9/13/72
                  0930-1430

5801                   1        2        3        4        5        6

           1 N       .0436    .0386    .0297    .0171    .0078   0.0000
                     .0053    .0050    .0044    .0033    .0023   0.0000

           1 HV      .0024    .0022    .0022    .0017    .0009   0.0000
                     .0013    .0012    .0012    .0011    .0008   0.0000

           1 LS      .0050    .0045    .0033    .0024    .0017   0.0000
                     .0018    .0017    .0015    .0013    .0011   0.0000

           1 HV+LS  0.0000   0.0000    .0002    .0005    .0002   0.0000
                    0.0000   0.0000    .0003    .0006    .0003   0.0000

VEHICLES   2 N       .0355    .0326    .0309    .0365    .0315    .0309
                     .0048    .0046    .0045    .0048    .0045    .0045

MOVING     2 HV      .0067    .0084    .0076    .0062    .0066    .0057
                     .0021    .0024    .0022    .0020    .0021    .0019

TOWARD     2 LS      .0009    .0017    .0022    .0033    .0079    .0103
                     .0008    .0011    .0012    .0015    .0023    .0026

MEDIAN     2 HV+LS   .0007    .0017    .0026    .0022    .0010    .0009
                     .0007    .0011    .0013    .0012    .0008    .0008

           3 N      0.0000    .0034    .0134    .0205    .0307    .0381
                    0.0000    .0015    .0030    .0036    .0044    .0049

           3 HV     0.0000    .0010    .0021    .0026    .0038    .0040
                    0.0000    .0008    .0012    .0013    .0016    .0016

           3 LS     0.0000   0.0000   0.0000    .0009    .0019    .0040
                    0.0000   0.0000   0.0000    .0008    .0011    .0016

           3 HV+LS  0.0000    .0005    .0007    .0009    .0009    .0010
                    0.0000    .0006    .0007    .0008    .0008    .0008
```

Before
%



After
%

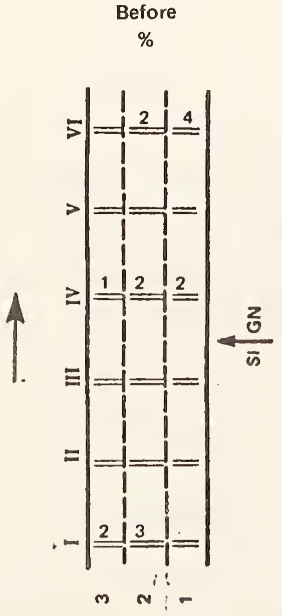


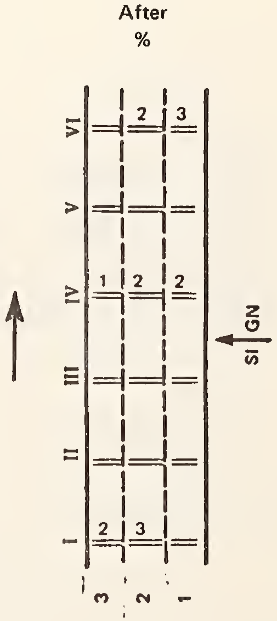
```
TOTALS    .0510    .0453    .0353    .0217    .0105   0.0000
LANE 1    .0057    .0054    .0048    .0038    .0026   0.0000

TOTALS    .0438    .0445    .0433    .0483    .0471    .0478
LANE 2    .0053    .0053    .0052    .0055    .0054    .0055

TOTALS   0.0000    .0050    .0162    .0248    .0372    .0471
LANE 3   0.0000    .0018    .0032    .0040    .0049    .0054
```

About 9% of the vehicles shifted lanes towards the median in both phases. Patterns of movement are very similar. At Traps 1, 4, and 6, the only significant difference is at Trap 4 in Lane 2 where the proportion of left moving vehicles was slightly higher in the After phase.

```
                      INTERCHANGE 18 EAST
                      ADVANCE (G-2) SIGN (BEFORE)
                      9/15/71
                      0930-1430

5136                       1       2       3       4       5       6

            1 N        .0382   .0337   .0243   .0167   .0068  0.0000
                       .0052   .0049   .0042   .0035   .0022  0.0000

            1 HV       .0021   .0019   .0021   .0025   .0008  0.0000
                       .0013   .0012   .0013   .0014   .0008  0.0000

            1 LS       .0041   .0039   .0027   .0025   .0010  0.0000
                       .0017   .0017   .0014   .0014   .0009  0.0000

            1 HV+LS    .0010   .0010   .0006   .0004   .0002  0.0000
                       .0009   .0009   .0007   .0005   .0004  0.0000

VEHICLES    2 N        .0300   .0273   .0267   .0249   .0275   .0255
                       .0047   .0045   .0044   .0043   .0045   .0043

 MOVING     2 HV       .0045   .0047   .0058   .0051   .0066   .0037
                       .0018   .0019   .0021   .0019   .0022   .0017

 TOWARD     2 LS       .0018   .0029   .0047   .0066   .0084   .0101
                       .0011   .0015   .0019   .0022   .0025   .0027

 MEDIAN     2 HV+LS    .0010   .0018   .0014   .0018   .0018   .0019
                       .0009   .0011   .0010   .0011   .0011   .0012

            3 N       0.0000   .0041   .0097   .0165   .0216   .0317     TOTALS     .0454    .0405    .0298    .0222    .0088  0.0000
                      0.0000   .0017   .0027   .0035   .0040   .0048     LANE 1     .0057    .0054    .0046    .0040    .0025  0.0000

            3 HV      0.0000  0.0000   .0010   .0014   .0016   .0019     TOTALS     .0372    .0366    .0386    .0384    .0442   .0413
                      0.0000  0.0000   .0009   .0010   .0011   .0012     LANE 2     .0052    .0051    .0053    .0053    .0056   .0054

            3 LS      0.0000   .0010   .0035   .0035   .0053   .0062     TOTALS    0.0000    .0055    .0142    .0220    .0296   .0413
                      0.0000   .0009   .0016   .0016   .0020   .0022     LANE 3    0.0000    .0020    .0032    .0040    .0046   .0054

            3 HV+LS   0.0000   .0004  0.0000   .0006   .0012   .0014
                      0.0000   .0005  0.0000   .0007   .0009   .0010
```

```
                    INTERCHANGE 18 EAST
                    AOVANCE (G-2) SIGN (AFTER)
                    9/13/72
                    0930-1430

5801                             1        2        3        4        5        6

              1 N           0.0000    .0043    .0110    .0184    .0245    .0298
                            0.0000    .0017    .0027    .0035    .0040    .0044

              1 HV          0.0000    .0003    .0007    .0003    .0005    .0010
                            0.0000    .0005    .0007    .0005    .0006    .0008

              1 LS          0.0000   0.0000    .0003    .0005    .0012    .0019
                            0.0000   0.0000    .0005    .0006    .0009    .0011

              1 HV+LS       0.0000   0.0000   0.0000    .0002   0.0000    .0002
                            0.0000   0.0000   0.0000    .0003   0.0000    .0003

VEHICLES      2 N            .0203    .0217    .0193    .0184    .0174    .0181
                             .0036    .0038    .0035    .0035    .0034    .0034

MOVING        2 HV           .0028    .0021    .0028    .0016    .0016    .0017
                             .0013    .0012    .0013    .0010    .0010    .0011

TOWARD        2 LS           .0076    .0055    .0033    .0026    .0010    .0003
                             .0022    .0019    .0015    .0013    .0008    .0005

SHOULDER      2 HV+LS        .0007    .0003    .0002   0.0000    .0002   0.0000
                             .0007    .0005    .0003   0.0000    .0003   0.0000

              3 N            .0178    .0157    .0138    .0086    .0059   0.0000
                             .0034    .0032    .0030    .0024    .0020   0.0000

              3 HV           .0012    .0012    .0010    .0016    .0007   0.0000
                             .0009    .0009    .0008    .0010    .0007   0.0000

              3 LS           .0028    .0017    .0007    .0009    .0002   0.0000
                             .0013    .0011    .0007    .0008    .0003   0.0000

              3 HV+LS       0.0000    .0002   0.0000   0.0000   0.0000   0.0000
                            0.0000    .0003   0.0000   0.0000   0.0000   0.0000
```





```
TOTALS     0.0000    .0047    .0121    .0195    .0262    .0329
LANE 1     0.0000    .0018    .0028    .0036    .0041    .0046

TOTALS      .0314    .0297    .0255    .0226    .0202    .0202
LANE 2      .0045    .0044    .0041    .0038    .0036    .0036

TOTALS      .0217    .0188    .0155    .0110    .0067   0.0000
LANE 3      .0038    .0035    .0032    .0027    .0021   0.0000
```

Patterns of movement for vehicles moving towards the shoulder are essentially identical in the Before and After phases. About 5% of the total population of vehicles performed such movements in both phases. There are no significant differences in the small totals tables for the Before and After phases.

```
                    INTERCHANGE 18 EAST
                    ADVANCE (G-2) SIGN (BEFORE)
                    9/15/71
                    0930-1430

5136                          1       2       3       4       5       6

              1 N        0.0000   .0033   .0111   .0187   .0251   .0306
                         0.0000   .0016   .0029   .0037   .0043   .0047

              1 HV       0.0000  0.0000   .0002   .0004   .0012   .0018
                         0.0000  0.0000   .0004   .0005   .0009   .0011

              1 LS       0.0000   .0002   .0010   .0023   .0025   .0033
                         0.0000   .0004   .0009   .0013   .0014   .0016

              1 HV+LS    0.0000   .0002   .0004   .0002   .0004   .0004
                         0.0000   .0004   .0005   .0004   .0005   .0005

VEHICLES      2 N         .0202   .0189   .0193   .0185   .0181   .0187
                          .0039   .0037   .0038   .0037   .0036   .0037

MOVING        2 HV        .0039   .0035   .0025   .0023   .0018   .0012
                          .0017   .0016   .0014   .0013   .0011   .0009

TOWARD        2 LS        .0080   .0092   .0064   .0033   .0027   .0010
                          .0024   .0026   .0022   .0016   .0014   .0009

SHOULDER      2 HV+LS     .0018   .0008   .0006   .0006   .0002  0.0000
                          .0011   .0008   .0007   .0007   .0004  0.0000

              3 N         .0173   .0162   .0121   .0082   .0037  0.0000     TOTALS   0.0000   .0037   .0127   .0216   .0292   .0360
                          .0036   .0034   .0030   .0025   .0017  0.0000     LANE 1   0.0000   .0017   .0031   .0040   .0046   .0051

              3 HV        .0012   .0010   .0008   .0006   .0006  0.0000     TOTALS    .0339   .0323   .0288   .0247   .0228   .0208
                          .0009   .0009   .0008   .0007   .0007  0.0000     LANE 2    .0049   .0048   .0046   .0042   .0041   .0039

              3 LS        .0037   .0035   .0023   .0018   .0006  0.0000     TOTALS    .0230   .0208   .0154   .0105   .0049  0.0000
                          .0017   .0016   .0013   .0011   .0007  0.0000     LANE 3    .0041   .0039   .0034   .0028   .0019  0.0000

              3 HV+LS     .0008   .0002   .0002  0.0000  0.0000  0.0000
                          .0008   .0004   .0004  0.0000  0.0000  0.0000
```

Summary. Interchange 18 East is a simple diamond interchange with a deceleration lane and single right-hand off ramp at the gore. Two of the three through lanes, the deceleration lane and the off ramp were instrumented at the gore. Of all traffic in the instrumented lanes, about 17 percent exited. Only about six percent of the nonauto traffic exited.

The change to diagrammatic signs was associated with a significant reduction in hazardous maneuvers at the gore. The reduction was particularly pronounced for the nonauto subpopulation (to one-half the level in the Before phase) and for vehicles coded as nonlocal (to one-third the level in the Before phase). Lane placement data showed that exiting traffic was particularly benefitted by the signs. Exiting vehicles entered the deceleration lane more promptly and performed fewer hazardous maneuvers. For through traffic, a reduction in the incidence of entries into the deceleration lane was found in the After phase.

For other measures used in the study, such as speed differences and headway violations, there were no consistent significant differences between the Before and After phases at the gore.

At the exit direction location, through maneuvers were significantly increased for autos and for the population as a whole. Except for this change, the reduction in hazardous maneuvers at the gore could not be traced back to the changes in vehicular maneuvers at the exit direction location. Increases in through maneuvers were not significant for other subpopulations. Preparatory maneuvers were not significantly increased in the After phase for any subpopulation.

The most significant change in the vicinity of the exit direction sign was a reduction in vehicles traversing the array at lower speeds (at least 5 mph less than the mean speed). In the Before phase, 21 percent of all vehicles met this criterion. In the After phase, only nine percent did. Headway violations were slightly increased in the After phase (in the order of two percent).

The reduction in hazardous maneuvers at the gore could not be traced back to changes in vehicular movements at the advance sign location. No significant changes in preparatory, through or other lane changes were found in the After phase. Patterns of movement for vehicles shifting lanes to the left toward the median and to the right toward the shoulder as they traversed the array were essentially the same in both phases.

There was a significant reduction in the proportion of vehicles traveling at least 5 mph less than the mean speed in the After phase. Nonautos showed a greater reduction in the proportion meeting this criterion than the other subpopulations. For autos and for the population as a whole, the reduction in the proportion of vehicles meeting the speed difference criterion was somewhat offset by a significant increase in headway violations. There was no significant increase in headway violations for nonautos.

In conclusion, a small improvement associated with the change to diagrammatics was found in a reduction of hazardous maneuvers at the gore. With the exception of a significant increase in through maneuvers for the auto subpopulation and for the population as a whole, the reductions seen at the gore could not be traced back to changes in behavior at the exit direction sign. Nor could they be traced back to changes in movements at the advance sign location. A significant reduction in lower speed vehicles was found at the exit direction and advance sign locations but not at the gore. The benefit of diagrammatics found at this interchange is small.

Interchange 18 West

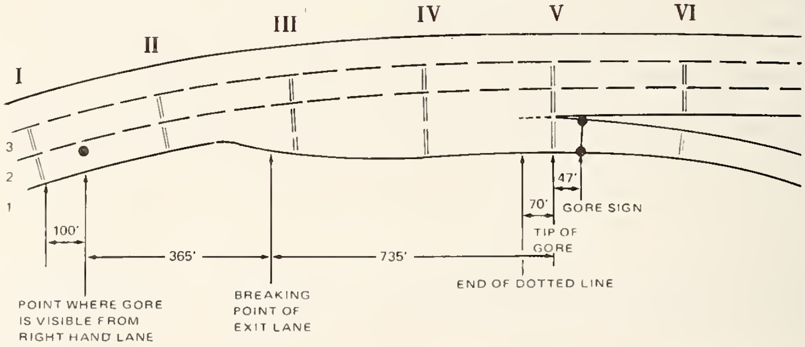
This interchange was used as a control. The signs remained conventional throughout the study.

The approach is three lanes wide and signed with an advance, exit direction and gore sign. The interchange is a simple diamond with a single exit to the right. The approach is associated with horizontal curvature to the left followed by a curve to the right. The curvature to the right prevents the motorist from seeing the gore from the exit direction location. The exit ramp is located near the top of a slight rise.

All sign locations were instrumented with the TES. The data collected at the gore are presented first, followed by results at the exit direction and advance sign locations.

Gore. Tapeswitches were deployed in the two shoulder-most lanes, the deceleration lane and the exit ramp. The median-most lane could not be instrumented because of limitations in the total inputs available on the TES. Tapeswitch instrumentation was as shown below:

Exit 18W Gore (Control Site)


I
II
III
IV
V
VI
3
2
1
100'
365'
735'
47'
70'
GORE SIGN
TIP OF GORE
END OF DOTTED LINE
POINT WHERE GORE IS VISIBLE FROM RIGHT HAND LANE
BREAKING POINT OF EXIT LANE

The average hourly percentage of traffic striking each trap in each lane was very similar for paired days in the Before and After phases. The range in average hourly percentages of vehicles recorded in each lane at the sixth trap collected over the four data collection days (two in the Before phase and two in the After phase) was:

		Total	Auto	Nonauto
Lane 1	(Exiting)	21-24	23-25	6-12
Lane 2	(Through)	23-24	18-21	64-67
Lane 3	(Through)	52-55	55-58	23-30

As can be seen, about 23 percent of the total traffic measured exited at the gore. Most of the traffic was automobile traffic. Proportionately fewer nonautos exited. Most of the nonauto traffic was found in the through lane closest to the shoulder, probably partly because of the vertical curve on the approach to the gore.

Mean absolute speed by lane and trap in the Before and After phases follows. Speeds recorded in the Before phase are about 1 mph faster at many trap locations. The same relationship in mean absolute speed between traps is found in both phases. Speeds in Lane 2 and Lane 1 (the deceleration lane) were several mph slower than those recorded in Lane 3 especially at the more downstream traps such as Traps 5 and 6. This may be due to the influence of the gore and/or the effect of the rising topography.

Tables showing the proportion of vehicles meeting the various criteria defined in Chapter V are presented next, followed by lane placement data for exiting and through traffic.

Data within each table (or each set of Before and After tables for the lane placement data) are paired by weekday. In other words, the first table shows data collected on October 6, 1971 and September 27, 1972, both Wednesday. Scheduled Before phase data collection was delayed by a week due to weather which accounts for the fact that data collected at this site are separated by a year and a week rather than the planned one year separation.

Each table is accompanied by annotations and, for lane placement data, illustrations which highlight features of the table.

```
                                         INTERCHANGE 18 WEST
                                         GOPE SIGN (BEFORE)
                                         10/6/71
                                         0930-1430


                        TRAP 1              TRAP 2              TRAP 3              TRAP 4              TRAP 5              TRAP 6
                               NON-                NON-                NON-                NON-                NON-                NCN-
ABSOLUTE SPEED     TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL
 LANF 1
   N                   0     0     0      0     0     0    130    69     8    928   517    44   1124   632    54   1123   632    54
   MEAN             0.00  0.00  0.00   0.00  0.00  0.00  49.55 49.34 53.36  49.66 49.76 51.13  46.41 46.64 47.51  40.62 40.90 41.60
   STAND DEV        0.00  0.00  0.00   0.00  0.00  0.00   7.67  8.72  6.23   5.55  5.72  4.52   5.78  5.94  5.25   5.57  5.69  5.12
   SKEWNESS         0.00  0.00  0.00   0.00  0.00  0.00   -.50  -.45  -.51    .06   .03   .05    .23   .15  -.10   -.00  -.12   .32
   KUPTOSIS         0.00  0.00  0.00   0.00  0.00  0.00   5.50  5.46  1.88   3.32  3.55  3.04   3.26  3.20  3.94   3.85  4.00  3.51

 LANE 2
   N                2345  1310   171   2308  1288   167   2171  1211   157   1368   759   123   1159   637   112   1148   624   113
   MEAN            50.27 50.30 50.73  50.91 50.87 51.60  51.39 51.37 51.99  51.21 51.12 51.92  50.46 50.30 51.40  49.13 48.92 50.07
   STAND DEV        6.14  6.20  5.47   6.00  6.08  5.42   6.00  6.06  5.24   6.37  6.54  5.77   7.00  7.08  6.86   7.31  7.40  7.32
   SKEWNESS         -.51  -.52  -.53   -.48  -.54  -.44   -.41  -.44  -.47   -.47  -.56  -.53   -.54  -.66  -.48   -.67  -.80  -.65
   KURTOSIS         4.82  4.43  4.21   4.42  4.63  4.29   4.41  4.53  4.60   4.56  4.91  4.67   4.61  5.09  4.49   4.64  5.15  4.65

 LANF 3
   N                2385  1188   221   2422  1210   225   2440  1225   227   2445  1229   225   2458  1236   226   2470  1249   225
   MEAN            54.15 54.07 53.78  56.58 56.49 56.24  57.32 57.19 57.29  58.14 57.96 58.23  57.53 57.39 57.48  56.55 56.39 56.42
   STAND DEV        4.79  5.01  4.83   4.87  4.95  5.34   4.91  4.98  5.23   5.09  5.11  5.46   5.41  5.38  6.06   5.84  5.79  7.46
   SKEWNESS          .51   .83   .05   -.05  -.11   .04   -.00  -.16   .15    .09   .04   .14   -.27  -.09  -.85  -1.03  -.25 -2.89
   KURTOSIS         8.91 12.56  4.09   4.43  4.92  5.02   4.42  4.87  4.56   3.72  3.67  4.35   5.73  5.00  8.53  18.34 17.22 23.81

                                        INTERCHANGE 18 WEST
                                        GORE SIGN (AFTER)
                                        9/27/72
                                        0930-1430

                   TRAP 1              TRAP 2              TRAP 3              TRAP 4              TRAP 5              TRAP 6
                          NON-                NCN-                NON-                NON-                NON-                NON-
ABSOLUTE SPEED TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL  TOTAL LOCAL LOCAL

 LANE 1
   N               0     0     0      0     0     0    452   239    31    718   386    41    868   464    43    874   466    45
   MEAN         0.00  0.00  0.00   0.00  0.00  0.00  49.64 49.80 47.62  48.27 48.16 47.32  43.89 43.89 42.10  39.74 39.65 37.85
   STAND DEV    0.00  0.00  0.00   0.00  0.00  0.00   5.63  5.50  6.80   5.51  5.43  5.95   5.35  5.14  5.36   5.15  5.04  4.75
   SKEWNESS     0.00  0.00  0.00   0.00  0.00  0.00   -.03  -.13   .05   -.01  -.09  -.02   -.05   .04  -.34   -.07  -.07  -.20
   KURTOSIS     0.00  0.00  0.00   0.00  0.00  0.00   3.27  2.90  2.61   3.24  3.41  2.25   3.51  3.33  2.81   3.17  3.29  2.10

 LANE 2
   N            2027   994   192   1905   924   187   1423   683   151   1164   540   138    953   436   131    940   432   129
   MEAN        48.60 48.63 47.92  49.59 49.67 48.77  49.95 49.97 49.27  49.28 49.44 48.61  48.02 48.22 47.42  48.65 49.09 47.72
   STAND DEV    7.17  7.07  6.74   6.41  6.31  6.68   6.37  6.34  6.50   6.49  6.41  6.82   6.97  6.85  7.06   8.07  7.95  8.31
   SKEWNESS     -.57  -.63   .04   -.36  -.52   .04   -.21  -.24   .07   -.23  -.17  -.07   -.28  -.29  -.06   -.29  -.32   .00
   KURTOSIS     5.26  6.41  2.74   3.76  4.49  2.81   3.44  3.86  2.83   3.32  3.61  2.78   3.27  3.64  2.71   3.25  3.79  2.52

 LANE 3
   N            1978   995   111   2100  1055   116   2149  1072   121   2142  1068   124   2203  1094   129   2210  1096   129
   MEAN        55.66 55.91 54.73  56.74 56.78 56.90  56.40 56.46 56.61  55.89 55.91 56.06  57.52 57.59 57.98  55.59 55.65 55.87
   STAND DEV    5.99  5.98  5.93   5.57  5.56  5.14   4.90  4.86  4.73   4.80  4.75  4.42   5.36  5.30  5.01   5.44  5.49  5.26
   SKEWNESS     -.10  -.25   .45   -.31  -.51  -.62   -.15   .00  -.38   -.10  -.03  -.43   -.06   .02  -.29    .42   .72  1.32
   KURTOSIS     5.56  6.51  5.05   5.72  7.93  4.14   3.84  4.03  3.07   3.43  3.49  3.44   3.65  3.92  3.25   5.94  6.96 10.14
```

	INTERCHANGE 18 WEST GORE SIGN (BEFORE) 10/6/71 0930-1430	INTERCHANGE 18 WEST GORE SIGN (AFTER) 9/27/72 0930-1430							
	AUTOS	AUTOS		NONAUTOS	NONAUTOS		ALL	ALL	
	4339	3572		402	452		4741	4024	
1. SPEED DIFFERENCE	.18622 .01158	.17833 .01255	N.S.	.49502 .04888	.49779 .04609	N.S.	.21240 .01164	.21421 .01268	N.S.
2. HEADWAY VIOLATION	.08458 .00828	.07251 .00850	↓	.03980 .01911	.02434 .01421	N.S.	.08078 .00776	.06710 .00773	↓
3. HAZARDOUS MANUEVERS	.03088 .00515	.03471 .00600	N.S.	.00498 .00688	.02655 .01482	↑	.02869 .00475	.03380 .00558	N.S.
4. 1 + 2	.04840 .00639	.05235 .00730	N.S.	.04478 .02022	.03761 .01754	N.S.	.04809 .00609	.05070 .00678	N.S.
5. 2 + 3	.00369 .00180	.00476 .00226	N.S.	.00249 .00487	.00221 .00433	N.S.	.00359 .00170	.00447 .00206	N.S.
6. 1 + 3	.01291 .00336	.01364 .00336	N.S.	.02736 .01595	.03319 .01651	N.S.	.01413 .00336	.01317 .00352	N.S.
7. 1 + 2 + 3	.00277 .00156	.00308 .00182	N.S.	0.00000 0.00000	.00442 .00512		.00253 .00143	.00323 .00175	N.S.
8. NORMAL	.63056 .01436	.64362 .01571	N.S.	.38557 .04758	.37389 .04461	N.S.	.60979 .01389	.61332 .01505	N.S.
9. DBL LANE CHANGES	.01798 .00395	.01036 .00332	↓	.00498 .00688	.01991 .01288	↑	.01687 .00367	.01143 .00328	↓

With few exceptions, there are no significant differences in these measures for the Before and After data collected on Wednesday in 1971 and 1972, respectively.

INTERCHANGE 18 WEST
GORE SIGN (BEFORE)
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INTERCHANGE 18 WEST
GORE SIGN (AFTER)
9/28/72
0930-1430

	AUTOS 4265	AUTOS 4187		NONAUTOS 424	NONAUTOS 438		ALL 4689	ALL 4625	
1. SPEED DIFFERENCE	.18664 .01169	.17913 .01162	N.S.	.43868 .04723	.45890 .04667	N.S.	.20943 .01165	.20562 .01165	N.S.
2. HEADWAY VIOLATION	.08253 .00826	.08837 .00860	N.S.	.02594 .01513	.02740 .01529	N.S.	.07742 .00765	.08259 .00793	N.S.
3. HAZARDOUS MANUEVERS	.03423 .00546	.02794 .00499	N.S.	.01887 .01295	.03653 .01757	N.S.	.03284 .00510	.02876 .00482	N.S.
4. 1 + 2	.04619 .00630	.05517 .00692	N.S.	.04009 .01867	.05251 .02089	N.S.	.04564 .00597	.05492 .00657	↑
5. 2 + 3	.00328 .00172	.00669 .00247	↑	.00236 .00462	.00685 .00772	N.S.	.00320 .00162	.00670 .00235	↑
6. 1 + 3	.01454 .00359	.01266 .00339	N.S.	.03774 .01814	.07078 .02402	↑	.01663 .00366	.01816 .00385	N.S.
7. 1 + 2 + 3	.00422 .00195	.00525 .00219	N.S.	.00472 .00652	.01598 .01174	N.S.	.00427 .00187	.00627 .00227	N.S.
8. NORMAL	.62837 .01450	.62479 .01467	N.S.	.43160 .04715	.33105 .04407	↓	.61058 .01396	.59697 .01414	N.S.
9. DBL LANE CHANGES	.02016 .00422	.01863 .00413	N.S.	.00472 .00652	0.00000 0.00000		.01877 .00388	.01686 .00371	N.S.

The Thursday paired data are similar to the Wednesday data. A few significant differences are found but they are different from the ones found in the Wednesday data. It must be remembered that the probability of a Type I error in these tests is .05. The fact that there is no consistency in the significant differences suggests that those found are attributable to Type I error.

INTERCHANGE 18 WEST
GORE SIGN (BEFORE)
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INTERCHANGE 18 WEST
GORE SIGN (AFTER)
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0930-1430

		LOCAL	LOCAL		FOREIGN	FOREIGN		ALL	ALL	
		2505	1994		392	303		2897	2297	
1.	SPEED DIFFERENCE	.20798 .01589	.20361 .01767	N.S.	.18878 .03874	.23432 .04769	N.S.	.20538 .01471	.20766 .01659	N.S.
2.	HEADWAY VIOLATION	.08184 .01073	.07422 .01151	N.S.	.05102 .02178	.05281 .02518	N.S.	.07767 .00975	.07140 .01053	N.S.
3.	HAZARDOUS MANUEVERS	.03313 .00701	.03460 .00802	N.S.	.03571 .01837	.02640 .01805	N.S.	.03348 .00655	.03352 .00736	N.S.
4.	1 + 2	.05509 .00893	.05216 .00976	N.S.	.03061 .01705	.04950 .02442	N.S.	.05178 .00807	.05181 .00906	N.S.
5.	2 + 3	.00319 .00221	.00652 .00353	N.S.	.00255 .00499	0.00000 0.00000		.00311 .00203	.00566 .00307	N.S.
6.	1 + 3	.01557 .00485	.01354 .00507	N.S.	.01020 .00995	.01983 .01569	N.S.	.01484 .00440	.01437 .00487	N.S.
7.	1 + 2 + 3	.00160 .00156	.00301 .00240	N.S.	.00255 .00499	0.00000 0.00000		.00173 .00151	.00261 .00239	N.S.
8.	NORMAL	.60160 .01917	.61234 .02139	N.S.	.67857 .04623	.61716 .05473	N.S.	.61201 .01774	.61297 .01992	N.S.
9.	DBL LANE CHANGES	.01796 .00520	.01354 .00507	N.S.	.01786 .01311	.00993 .01115	N.S.	.01795 .00483	.01306 .00464	N.S.

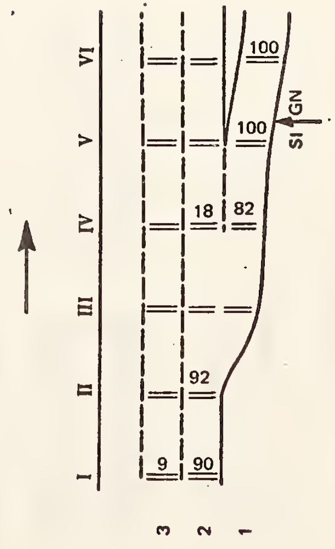
No significant differences were found in the local and foreign subpopulations of vehicles in the Before and After phases.

From the three tables which have been presented, it is concluded that traffic behavior as measured by the criteria indicated in the tables was not significantly different in the Before and After phases.

```
INTERCHANGE 18 WEST
GORE SIGN (AFTER)
9/27/72
0930-1430

EXIT TRAFFIC                       TRAP
874                1        2        3        4        5        6

       1 N        .0137    .0160    .3922    .6773    .8318    .8673
                  .0077    .0093    .0322    .0310    .0248    .0225

       1 HV       .0023    .0011    .0183    .0240    .0309    .0240
                  .0032    .0022    .0089    .0102    .0115    .0102

       1 LS       .0023    .0011    .0549    .0961    .1064    .0961
                  .0032    .0022    .0151    .0195    .0204    .0195

       1 HV+LS    .0023    .0023    .0103    .0126    .0149    .0126
                  .0032    .0032    .0067    .0074    .0080    .0074

       2 N        .7380    .7723    .4027    .1533    .0126   0.0000
                  .0292    .0278    .0325    .0239    .0074   0.0000

       2 HV       .0824    .0584    .0297    .0057   0.0000   0.0000
                  .0182    .0155    .0113    .0050   0.0000   0.0000

       2 LS       .7744    .7739    .0561    .0229    .0023   0.0000
                  .0174    .0170    .0153    .0099    .0032   0.0000

       2 HV+LS    .7379    .7720    .0183   0.0000   0.0000   0.0000
                  .0126    .0117    .0089   0.0000   0.0000   0.0000

       3 N        .0309    .0320    .0137    .0046    .0011   0.0000
                  .0115    .0117    .0077    .0045    .0022   0.0000

       3 HV       .0046    .0069    .0023    .0011   0.0000   0.0000
                  .0045    .0055    .0032    .0022   0.0000   0.0000

       3 LS       .0080    .0057    .0103    .0023   0.0000   0.0000
                  .0059    .0050    .0067    .0032   0.0000   0.0000

       3 HV+LS    .0034    .0011    .0011   0.0000   0.0000   0.0000
                  .0039    .0022    .0022   0.0000   0.0000   0.0000
```

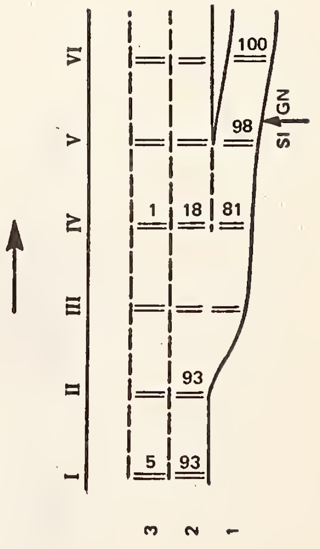
Before

%



After

%



```
TOTALS     .0206    .0206    .4657    .8101    .9840   1.0000
LANE 1     .0094    .0094    .0331    .0260    .0083   0.0000

TOTALS     .9325    .9336    .5069    .1819    .0149   0.0000
LANE 2     .0166    .0165    .0331    .0256    .0080   0.0000

TOTALS     .0469    .0458    .0275    .0080    .0011   0.0000
LANE 3     .0140    .0139    .0108    .0059    .0022   0.0000
```

Although a significantly higher proportion of exiting vehicles entered the array in Lane 2, lane usage of exiting vehicles at the fourth trap is not significantly different for the Wednesday Before/After data. Thus, the slight improvement in lane placement at Trap 1 is not continued into the gore. (The data at Trap 3 in Lane 1, the deceleration lane, should be ignored in this and subsequent tables because of problems associated with placement and use of this trap.)

```
                    INTERCHANGE 18 WEST
                    GORE SIGN (BEFORE)
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                    0930-1430

EXIT TRAFFIC                            TRAP
   1123                   1       2       3       4       5       6

           1 N          .0062   .0062   .0748   .6215   .7453   .7542
                        .0046   .0046   .0154   .0284   .0255   .0252

           1 HV         .0009   .0018   .0107   .0321   .0258   .0294
                        .0017   .0025   .0060   .0103   .0093   .0099

           1 LS         .0009   .0009   .0178   .1454   .2021   .2004
                        .0017   .0017   .0077   .0205   .0235   .0234

           1 HV+LS      .0018   .0009   .0027   .0196   .0223   .0160
                        .0025   .0017   .0030   .0081   .0086   .0073

           2 N          .7070   .7222   .6679   .1443   .0036  0.0000
                        .0266   .0262   .0275   .0205   .0035  0.0000

           2 HV         .0606   .0641   .0668   .0053  0.0000  0.0000
                        .0139   .0143   .0146   .0043  0.0000  0.0000

           2 LS         .1122   .1024   .1060   .0276  0.0000  0.0000
                        .0185   .0177   .0180   .0096  0.0000  0.0000

           2 HV+LS      .0249   .0303   .0294   .0018  0.0000  0.0000
                        .0091   .0100   .0099   .0025  0.0000  0.0000

           3 N          .0614   .0490   .0178   .0036  0.0000  0.0000     TOTALS      .0099   .0098   .1060   .8166   .9955  1.0000
                        .0140   .0126   .0077   .0035  0.0000  0.0000     LANE 1      .0058   .0058   .0180   .0226   .0039  0.0000

           3 HV         .0107   .0098   .0018  0.0000  0.0000  0.0000     TOTALS      .9047   .9190   .8700   .1790   .0036  0.0000
                        .0060   .0058   .0025  0.0000  0.0000  0.0000     LANE 2      .0172   .0160   .0197   .0224   .0035  0.0000

           3 LS         .0125   .0116   .0045   .0009   .0009  0.0000     TOTALS      .0855   .0712   .0248   .0045   .0009  0.0000
                        .0065   .0063   .0039   .0017   .0017  0.0000     LANE 3      .0164   .0150   .0090   .0039   .0017  0.0000

           3 HV+LS      .0009   .0009  0.0000  0.0000  0.0000  0.0000
                        .0017   .0017  0.0000  0.0000  0.0000  0.0000
```
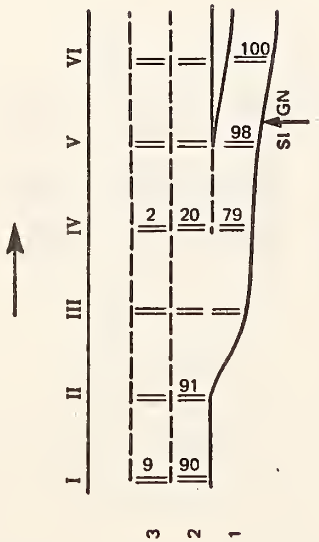

INTERCHANGE 18 WEST
GORE SIGN (AFTER)
9/28/72
0930-1430

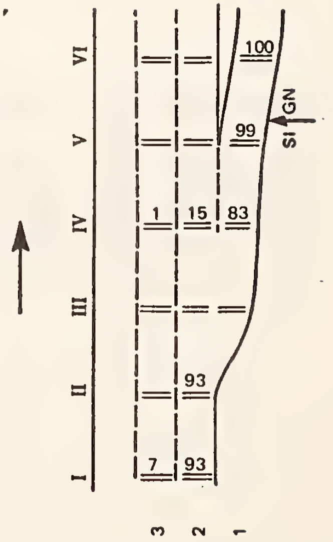
EXIT TRAFFIC
982

	TRAP 1	2	3	4	5	6
1 N	.0010 .0020	.0010 .0020	.3900 .0305	.6375 .0301	.7821 .0258	.7678 .0264
1 HV	0.0000 0.0000	0.0000 0.0000	.0163 .0079	.0295 .0106	.0346 .0114	.0407 .0124
1 LS	0.0000 0.0000	0.0000 0.0000	.0621 .0151	.1385 .0216	.1436 .0219	.1580 .0234
1 HV+LS	0.0000 0.0000	0.0000 0.0000	.0112 .0066	.0285 .0104	.0295 .0106	.0234 .0095
2 N	.6762 .0293	.7067 .0285	.3676 .0302	.1191 .0203	.0061 .0049	0.0000 0.0000
2 HV	.1171 .0201	.0876 .0177	.0275 .0102	.0020 .0028	0.0000 0.0000	0.0000 0.0000
2 LS	.0937 .0182	.0978 .0186	.0642 .0153	.0295 .0106	.0020 .0028	0.0000 0.0000
2 HV+LS	.0387 .0121	.0428 .0127	.0153 .0077	.0020 .0028	0.0000 0.0000	0.0000 0.0000
3 N	.0468 .0132	.0418 .0125	.0275 .0102	.0071 .0053	.0020 .0028	0.0000 0.0000
3 HV	.0112 .0066	.0112 .0066	.0061 .0049	.0031 .0035	0.0000 0.0000	0.0000 0.0000
3 LS	.0122 .0069	.0092 .0060	.0102 .0063	.0031 .0035	0.0000 0.0000	0.0000 0.0000
3 HV+LS	.0031 .0035	.0020 .0028	.0020 .0028	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000

Before
%



After
%

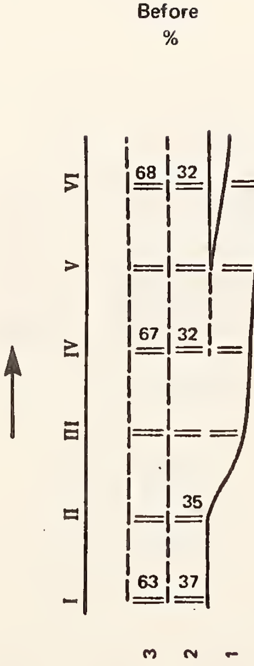


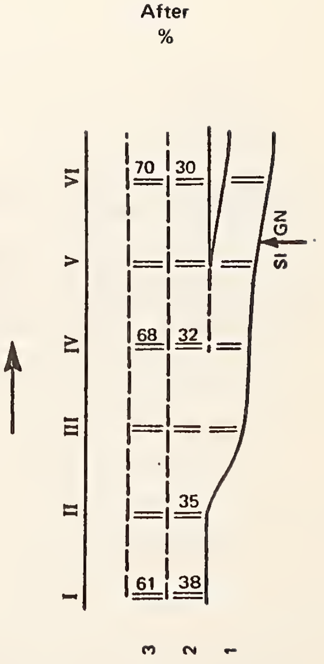
TOTALS LANE 1	.0010 .0020	.0010 .0020	.4796 .0312	.8340 .0233	.9898 .0063	1.0000 0.0000
TOTALS LANE 2	.9257 .0164	.9348 .0154	.4745 .0312	.1527 .0225	.0081 .0056	0.0000 0.0000
TOTALS LANE 3	.0733 .0163	.0642 .0153	.0458 .0131	.0132 .0071	.0020 .0028	0.0000 0.0000

The Thursday data suggest a possible slight improvement in lane usage by exiting traffic (see proportions at Trap 4). However, since the differences are small and are not consistent with the Wednesday data, it is concluded that lane usage by exiting traffic has not significantly changed in the one year separation between Before and After phases at the gore of the control interchange.

```
                     INTERCHANGE 18 WEST
                     GORE SIGN (BEFORE)
                     10/7/71
                     0930-1430

EXIT TRAFFIC                         TRAP
   1077                1      2      3      4      5      6

          1 N        .0056  .0056  .1012  .6017  .7382  .7679
                     .0044  .0044  .0180  .0292  .0263  .0252

          1 HV       .0028  .0028  .0084  .0381  .0316  .0316
                     .0031  .0031  .0054  .0114  .0104  .0104

          1 LS       .0037  .0037  .0232  .1263  .1876  .1801
                     .0036  .0036  .0090  .0198  .0233  .0230

          1 HV+LS    .0009  .0009  .0056  .0195  .0251  .0204
                     .0018  .0018  .0044  .0083  .0093  .0084

          2 N        .6955  .7103  .6295  .1504  .0102 0.0000
                     .0275  .0271  .0288  .0214  .0060 0.0000

          2 HV       .0678  .0650  .0715  .0065 0.0000 0.0000
                     .0150  .0147  .0154  .0048 0.0000 0.0000

          2 LS       .1049  .1068  .1003  .0381  .0046 0.0000
                     .0183  .0184  .0179  .0114  .0041 0.0000

          2 HV+LS    .0297  .0306  .0260  .0019  .0009 0.0000
                     .0101  .0103  .0095  .0026  .0018 0.0000

          3 N        .0669  .0576  .0269  .0121 0.0000 0.0000   TOTALS    .0130  .0130  .1383  .7855  .9824 1.0000
                     .0149  .0139  .0097  .0065 0.0000 0.0000   LANE 1    .0068  .0068  .0206  .0245  .0079 0.0000

          3 HV       .0139  .0074  .0046  .0019  .0009 0.0000   TOTALS    .8979  .9127  .8273  .1968  .0158 0.0000
                     .0070  .0051  .0041  .0026  .0018 0.0000   LANE 2    .0181  .0169  .0226  .0237  .0074 0.0000

          3 LS       .0065  .0074  .0019  .0037  .0009 0.0000   TOTALS    .0891  .0743  .0344  .0176  .0019 0.0000
                     .0048  .0051  .0026  .0036  .0018 0.0000   LANE 3    .0170  .0157  .0109  .0079  .0026 0.0000

          3 HV+LS    .0019  .0019  .0009 0.0000 0.0000 0.0000
                     .0026  .0026  .0018 0.0000 0.0000 0.0000
```

```
INTERCHANGE 18 WEST
GORE SIGN (AFTER)
9/27/72
0930-1430

THRU TRAFFIC                              TRAP
   3150              1        2        3        4        5        6

      1 N          .0003    .0003    .0098    .0025    .0022   0.0000
                   .0006    .0006    .0034    .0018    .0016   0.0000

      1 HV        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

      1 LS        0.0000   0.0000    .0044    .0006    .0003   0.0000
                  0.0000   0.0000    .0023    .0009    .0006   0.0000

      1 HV+LS     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

      2 N          .2892    .2683    .2489    .2578    .2387    .2314
                   .0158    .0155    .0151    .0153    .0149    .0147

      2 HV         .0156    .0086    .0048    .0057    .0041    .0035
                   .0043    .0032    .0024    .0026    .0022    .0021

      2 LS         .0708    .0663    .0565    .0543    .0546    .0619
                   .0090    .0087    .0081    .0079    .0079    .0084

      2 HV+LS      .0092    .0025    .0010    .0013    .0010    .0016
                   .0033    .0018    .0011    .0012    .0011    .0014

      3 N          .4983    .5390    .5746    .5737    .5771    .5689
                   .0175    .0174    .0173    .0173    .0173    .0173

      3 HV         .0222    .0197    .0197    .0203    .0273    .0359
                   .0051    .0049    .0049    .0049    .0057    .0065

      3 LS         .0890    .0911    .0740    .0790    .0898    .0889
                   .0104    .0100    .0091    .0094    .0100    .0099

      3 HV+LS      .0054    .0041    .0063    .0048    .0048    .0079
                   .0026    .0022    .0028    .0024    .0024    .0031
```


Before
%

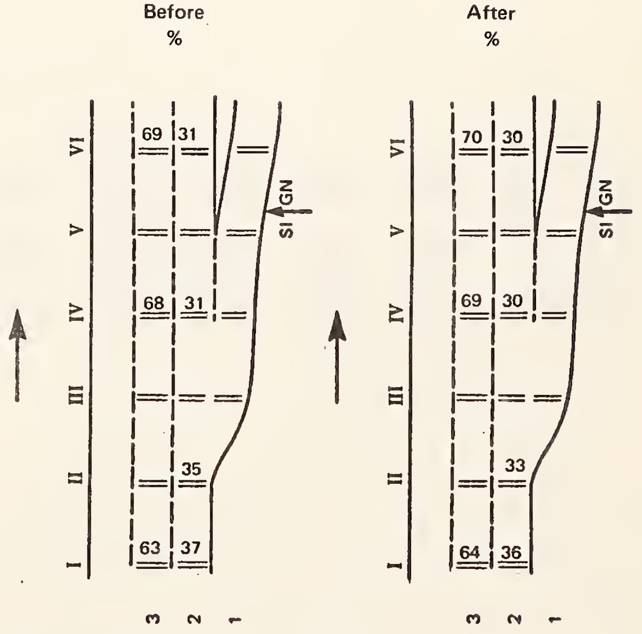

After
%

```
TOTALS    .0003    .0003    .0143    .0032    .0025   0.0000
LANE 1    .0006    .0006    .0041    .0020    .0018   0.0000

TOTALS    .3848    .3457    .3111    .3190    .2984    .2984
LANE 2    .0170    .0166    .0162    .0163    .0160    .0160

TOTALS    .6149    .6540    .6746    .6778    .6990    .7016
LANE 3    .0170    .0166    .0164    .0163    .0160    .0160
```

There are no significant differences in lane usage for through vehicles between the Before and After phases (based on testing the proportions of vehicles crossing Traps 1, 4 and 6 for significance).

```
                  INTERCHANGE 18 WEST
                  GORE SIGN (BEFORE)
                  10/6/71
                  0930-1430


THRU TRAFFIC                          TRAP
   3618                1       2       3       4       5       6

           1 N      0.0000  0.0000   .0017   .0022   .0011  0.0000
                    0.0000  0.0000   .0013   .0015   .0011  0.0000

           1 HV     0.0000  0.0000  0.0000   .0003  0.0000  0.0000
                    0.0000  0.0000  0.0000   .0005  0.0000  0.0000

           1 LS     0.0000  0.0000   .0014   .0006   .0006  0.0000
                    0.0000  0.0000   .0012   .0008   .0008  0.0000

           1 HV+LS  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
                    0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

           2 N       .2924   .2805   .2615   .2573   .2515   .2493
                     .0148   .0146   .0143   .0142   .0141   .0141

           2 HV      .0130   .0133   .0122   .0058   .0044   .0039
                     .0037   .0037   .0036   .0025   .0022   .0020

           2 LS      .0561   .0539   .0528   .0564   .0608   .0608
                     .0075   .0074   .0073   .0075   .0078   .0078

           2 HV+LS   .0058   .0050   .0036   .0030   .0025   .0033
                     .0025   .0023   .0019   .0018   .0016   .0019

           3 N       .5274   .5340   .5453   .5345   .5271   .5171    TOTALS   0.0000  0.0000   .0030   .0030   .0017  0.0000
                     .0163   .0163   .0162   .0163   .0163   .0163    LANE 1   0.0000  0.0000   .0018   .0018   .0013  0.0000

           3 HV      .0282   .0293   .0276   .0301   .0365   .0467    TOTALS    .3673   .3527   .3300   .3226   .3192   .3173
                     .0054   .0055   .0053   .0056   .0061   .0069    LANE 2    .0157   .0156   .0153   .0152   .0152   .0152

           3 LS      .0694   .0802   .0854   .1020   .1083   .1092    TOTALS    .6327   .6473   .6669   .6744   .6791   .6827
                     .0083   .0088   .0091   .0099   .0101   .0102    LANE 3    .0157   .0156   .0154   .0153   .0152   .0152

           3 HV+LS   .0077   .0039   .0086   .0077   .0072   .0097
                     .0029   .0020   .0030   .0029   .0028   .0032
```

```
                INTERCHANGE 18 WEST
                GORE SIGN (AFTER)
                9/28/72
                0930-1430

THRU TRAFFIC                             TRAP
   3643                  1        2        3        4        5        6

         1 N           .0003    .0005    .0137    .0027    .0016   0.0000
                       .0005    .0008    .0038    .0017    .0013   0.0000

         1 HV          .0003   0.0000    .0005    .0005    .0005   0.0000
                       .0005   0.0000    .0008    .0008    .0008   0.0000

         1 LS          .0005    .0005    .0113    .0008    .0003   0.0000
                       .0008    .0008    .0034    .0009    .0005   0.0000

         1 HV+LS      0.0000   0.0000    .0003   0.0000   0.0000   0.0000
                      0.0000   0.0000    .0005   0.0000   0.0000   0.0000

         2 N           .2516    .2547    .2317    .2416    .2336    .2339
                       .0143    .0141    .0137    .0139    .0137    .0137

         2 HV          .0187    .0126    .0077    .0055    .0016    .0027
                       .0044    .0036    .0028    .0024    .0013    .0017

         2 LS          .0656    .0601    .0491    .0552    .0552    .0574
                       .0080    .0077    .0070    .0074    .0074    .0076

         2 HV+LS       .0113    .0041    .0019    .0022    .0030    .0033
                       .0034    .0021    .0014    .0015    .0018    .0019

         3 N           .5207    .5438    .5641    .5671    .5561    .5490
                       .0162    .0162    .0161    .0161    .0161    .0162

         3 HV          .0280    .0305    .0327    .0357    .0365    .0445
                       .0054    .0056    .0058    .0060    .0061    .0067

         3 LS          .0873    .0876    .0807    .0815    .1035    .1013
                       .0092    .0092    .0088    .0089    .0099    .0098

         3 HV+LS       .0058    .0055    .0063    .0071    .0080    .0080
                       .0025    .0024    .0026    .0027    .0029    .0029
```



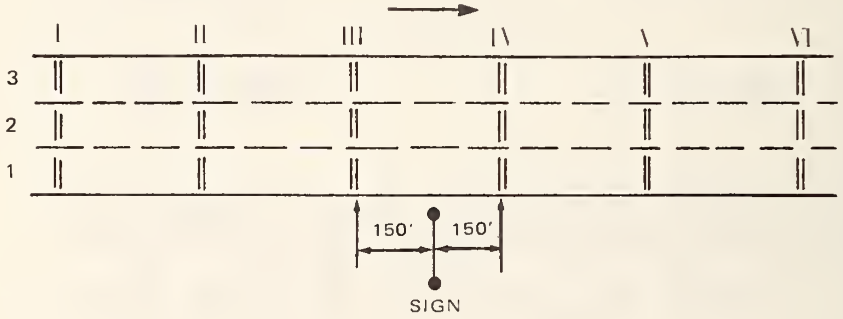
```
TOTALS      .0011     .0011     .0258     .0041     .0025    0.0000
LANE 1      .0011     .0011     .0051     .0021     .0016    0.0000

TOTALS      .3571     .3316     .2904     .3044     .2934     .2973
LANE 2      .0156     .0153     .0147     .0149     .0148     .0148

TOTALS      .6418     .6673     .6838     .6915     .7041     .7027
LANE 3      .0156     .0153     .0151     .0150     .0148     .0148
```

The Thursday data for lane usage for through vehicles confirm the Wednesday data. Distribution of through vehicles across the instrumented lanes was not significantly different in the After phase compared to the Before phase.

```
                    INTERCHANGE 18 WEST
                    GORE SIGN (BEFORE)
                    10/7/71
                    0930-1430

THRU TRAFFIC                                 TRAP
   3612                     1         2         3         4         5         6

           1 N          0.0000    0.0000     .0011     .0039     .0019    0.0000
                        0.0000    0.0000     .0011     .0020     .0014    0.0000

           1 HV         0.0000    0.0000    0.0000     .0006     .0003    0.0000
                        0.0000    0.0000    0.0000     .0008     .0005    0.0000

           1 LS         0.0000     .0003     .0022     .0022     .0003    0.0000
                        0.0000     .0005     .0015     .0015     .0005    0.0000

           1 HV+LS       .0006     .0003     .0006     .0006     .0006    0.0000
                         .0008     .0005     .0008     .0008     .0008    0.0000

           2 N           .2949     .2816     .2616     .2536     .2508     .2475
                         .0149 [illegible]   .0143     .0142     .0141     .0141

           2 HV          .0122     .0108     .0091     .0061     .0030     .0036
                         .0036     .0034     .0031     .0025     .0018     .0020

           2 LS          .0615     .0548     .0537     .0523     .0537     .0523
                         .0078     .0074     .0074     .0073     .0074     .0073

           2 HV+LS       .0028     .0022     .0028     .0025     .0025     .0019
                         .0017     .0015     .0017     .0016     .0016     .0014

           3 N           .5136     .5307     .5393     .5346     .5484     .5374      TOTALS      .0006     .0006     .0039     .0072     .0030    0.0000
                         .0163     .0163     .0163     .0163     .0162     .0163      LANE 1      .0008     .0008     .0020     .0028     .0018    0.0000

           3 HV          .0288     .0282     .0307     .0324     .0282     .0424      TOTALS      .3713     .3494     .3272     .3145     .3101     .3054
                         .0055     .0054     .0056     .0058     .0054     .0066      LANE 2      .0158     .0155     .0153     .0151     .0151     .0150

           3 LS          .0783     .0831     .0916     .1022     .1019     .1044      TOTALS      .6282     .6501     .6689     .6783     .6869     .6946
                         .0088     .0090     .0094     .0099     .0099     .0100      LANE 3      .0158     .0156     .0153     .0152     .0151     .0150

           3 HV+LS       .0075     .0080     .0072     .0091     .0083     .0105
                         .0028     .0029     .0028     .0031     .0030     .0033
```

To summarize the results at the gore of the control interchange, traffic behavior was unchanged in the After phase when evaluated by the measures used in this study. The incidence of speed differences, headway violations, hazardous maneuvers and combinations of these remained very stable from one year to the next. Lane placement for exiting and through traffic subpopulations were also quite unaffected by the one year time span between phases.

Exit Direction (G-1) Location. All three lanes of the approach were instrumented with tapeswitches in the Before and After phases. The switches were deployed symmetrically about the sign. The array thus extended from 750 feet upstream from the sign to 750 feet downstream from it.



Data collection in the Before phase occurred on Monday and Tuesday (August 30 and 31, 1971, respectively) and was scheduled for the equivalent days in the After phase (Monday and Tuesday, August 28 and 29, 1972, respectively). However, poor weather prevented tapeswitch deployment for Monday in the After phase. Thus, only Tuesday data are presented in the following discussion.

There was little difference in the percent volume in each lane in the Before and After phases. The mean hourly volume of traffic expressed as a percentage by vehicle type is shown below at the sixth trap:

	Total		Auto		Nonauto	
	8/31/71	8/29/72	8/31/71	8/29/72	8/31/71	8/29/72
Lane 1	40.0	38.3	37.7	35.9	66.7	69.7
Lane 2	44.3	42.6	45.6	43.8	28.1	27.1
Lane 3	15.7	19.1	16.6	20.3	5.2	3.2

As is apparent, the majority of the traffic volume measured was located in Lanes 1 and 2. About two-thirds of the nonauto traffic was found in Lane 1. Only three to five percent used Lane 3. Distribution of vehicles by lane was very similar in the Before and After phase.

Vehicle speed in all lanes increased as the tapeswitch array was traversed from Trap 1 to Trap 6. This was seen in all lanes and in both the Before and After data. Absolute mean speed data at Traps 1 and 6 in the Before and After study were:

	Trap 1		Trap 6	
	8/31/71	8/29/72	8/31/71	8/20/72
Lane 1	48.55	49.17	50.52	51.77
Lane 2	53.53	54.95	56.48	57.53
Lane 3	55.25	55.95	59.42	60.56

Absolute mean speeds were slightly higher in the After study.

Tables on the following pages present the proportions of vehicles performing various types of lane changes and meeting the criteria for speed difference and headway violations.

INTERCHANGE 18 WEST
ADVANCE (G-1) SIGN (BEFORE)
8/31/71
0930-1430

INTERCHANGE 18 WEST
ADVANCE (G-1) SIGN (AFTER)
8/29/72
0930-1430

		AUTOS	AUTOS		NONAUTOS	NONAUTOS		ALL	ALL	
		5109	6821		441	502		5550	7323	
1.	PREP. MANUEVERS	.09454 .00802	.05718 .00551	↓	.06803 .02350	.07371 .02286	N.S.	.09243 .00762	.05831 .00537	↓
2.	THROUGH MANUEVERS	.07731 .00732	.05732 .00552	↓	.06576 .02313	.05179 .01939	N.S.	.07640 .00699	.05694 .00531	↓
3.	OTHER LANE CHANGES	.06890 .00695	.06011 .00564	N.S.	.01134 .00988	.01594 .01095	N.S.	.06432 .00645	.05708 .00531	N.S.
4.	NO LANE CHANGES	.75925 .01172	.82539 .00901	↑	.85488 .03287	.85857 .03048	N.S.	.76685 .01112	.82767 .00865	↑
1.	SPEED DIFFERENCE	.16363 .01014	.16845 .00888	N.S.	.44218 .04635	.50797 .04373	↑	.18577 .01023	.19172 .00902	N.S.
2.	HEADWAY VIOLATION	.12272 .00900	.12447 .00783	N.S.	.07937 .02523	.05777 .02041	N.S.	.11928 .00853	.11990 .00744	N.S.
3.	DBL LANE CHANGES	.01468 .00330	.00323 .00135	↓	0.00000 0.00000	0.00000 0.00000		.01351 .00304	.00300 .00125	↓
4.	1 + 2	.06087 .00656	.06961 .00500	N.S.	.07256 .02421	.05976 .02074	N.S.	.06180 .00634	.06800 .00577	N.S.
5.	2 + 3	.00391 .00171	.00205 .00107	N.S.	.00227 .00444	0.00000 0.00000		.00378 .00162	.00191 .00100	N.S.
6.	1 + 3	.00665 .00223	.00191 .00104	↓	.00454 .00627	.00398 .00551	N.S.	.00649 .00211	.00205 .00104	↓
7.	1 + 2 + 3	.00313 .00153	.00235 .00115	N.S.	.00454 .00627	.00199 .00390	N.S.	.00324 .00150	.00232 .00110	N.S.
8.	NORMAL	.62439 .01328	.62894 .01146	N.S.	.39456 .04562	.36853 .04220	N.S.	.60613 .01285	.61109 .01117	N.S.

The reduction in preparatory and through maneuvers in the After phase is significant at the .05 level or better as is the increase in the proportion of vehicles performing no lane changes. Because these results appear to have no significant impact on traffic behavior at the gore (e.g., improved lane placement, reduced erratic maneuvers), this change in traffic behavior at the exit direction sign should not be interpreted as indicating improved performance in the After phase.

With regard to the other criteria (beneath the dashed line), there are few significant differences. It will be noted that the proportion of vehicles classified as normal was not significantly different in the After phase.

INTERCHANGE 18 WEST
ADVANCE (G-1) SIGN (BEFORE)
8/31/71
0930-1430

INTERCHANGE 18 WEST
ADVANCE (G-1) SIGN (AFTER)
8/29/72
0930-1430

	LOCAL	LOCAL		FOREIGN	FOREIGN		ALL	ALL	
	2698	4272		299	596		2997	4868	
1. PREP. MANUEVERS	.08488 .01052	.05641 .00692	↓	.08027 .03080	.04027 .01578	↓	.08442 .00995	.05444 .00637	↓
2. THROUGH MANUEVERS	.07635 .01002	.05548 .00686	↓	.09365 .03302	.05369 .01810	↓	.07808 .00961	.05526 .00642	↓
3. OTHER LANE CHANGES	.06894 .00956	.06180 .00722	N.S.	.05686 .02625	.06040 .01913	N.S.	.06773 .00900	.06163 .00676	N.S.
4. NO LANE CHANGES	.76983 .01588	.82631 .01136	↑	.76923 .04776	.84564 .02901	↑	.76977 .01507	.82868 .01058	↑
1. SPEED DIFFERENCE	.18236 .01457	.19727 .01170	N.S.	.19398 .04482	.17617 .03059	N.S.	.18352 .01386	.18591 .01093	N.S.
2. HEADWAY VIOLATION	.11675 .01212	.12125 .00979	N.S.	.10033 .03406	.09899 .02398	N.S.	.11512 .01143	.11853 .00998	N.S.
3. DBL LANE CHANGES	.01520 .00462	.00328 .00171	↓	.00334 .00654	.00168 .00329	N.S.	.01401 .00421	.00308 .00156	↓
4. 1 + 2	.06523 .00932	.06835 .00757	N.S.	.05017 .02474	.04698 .01699	N.S.	.06373 .00875	.06574 .00696	N.S.
5. 2 + 3	.00445 .00251	.00257 .00152	N.S.	0.00000 0.00000	0.00000 0.00000		.00400 .00226	.00226 .00133	N.S.
6. 1 + 3	.00741 .00324	.00211 .00137	↓	0.00000 0.00000	.00336 .00464		.00667 .00291	.00226 .00133	↓
7. 1 + 2 + 3	.00334 .00218	.00211 .00137	N.S.	.00334 .00654	.00168 .00329	N.S.	.00334 .00206	.00205 .00127	N.S.
8. NORMAL	.60526 .01844	.61306 .01461	N.S.	.64883 .05411	.67114 .03772	N.S.	.60961 .01747	.62017 .01363	N.S.

The data for the local and foreign subpopulations reflect those found previously for the population as a whole and for the auto subpopulation. A similar interpretation holds for these data.

Attention is next turned to lane placement data in which the total population of vehicles was divided into four subpopulations; vehicles not changing lanes, vehicles moving towards the median, vehicles moving towards the shoulder and vehicles moving in both directions. As has been seen in the previous tables, the proportion of vehicles not changing lanes was roughly in the order of 80 percent and was significantly higher in the After phase. The distribution of these vehicles by lane in the Before and After phase (the top number is the proportion; the bottom number is the 95 percent confidence limit) was:

	8/31/71	8/29/72
Lane 1	.3186 .0123	.3255 .0107
Lane 2	.3195 .0123	.3273 .0107
Lane 3	.1029 .0080	.1482 .0081

The only significantly different proportion is that for the vehicles in Lane 3 which was significantly higher in the After phase. Thus, the higher proportion of vehicles not changing lanes in the After phase is due to the increase of such vehicles in Lane 3.

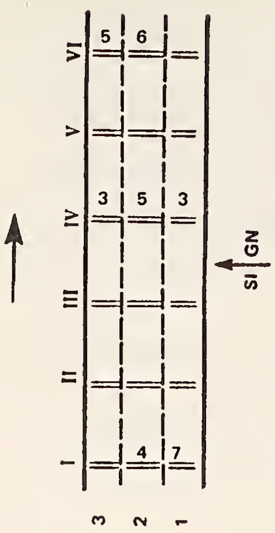
The proportion of vehicles changing lanes in both directions within the tapeswitch array was .0290 ± .0044 in the Before phase and .0153 ± .0028 in the After phase. These differences are not significant.

The four tables following present lane placement information for vehicles moving towards the median and towards the shoulder in the Before and After phases. The significant differences between the proportions in the small tables at the right in the Before and After data reflect the significant decrease in preparatory and through maneuvers already found. However, it can be seen that the patterns of movement are the same in the Before and After data and that changes in these patterns have not occurred over the one year time span intervening between phases.

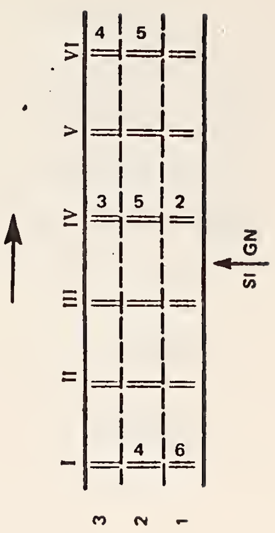
The overall findings at the exit direction location are that by most criteria (such as speed differences, the proportion of vehicles in the normal category and patterns of lane usage), there are no significant differences in the Before and After phases. Although preparatory and through maneuvers were decreased in the After phase, no significant change in lane placement or hazardous maneuvers was found at the gore. Thus, these decreases had no significant impact on behavior in negotiating the gore area.

```
                    INTERCHANGE 18 WEST
                    ADVANCE (G-1) SIGN (AFTER)
                    8/29/72
                    0930-1430

7323                      1        2        3        4        5        6

           1  N         .0433    .0325    .0220    .0120    .0038   0.0000
                        .0047    .0041    .0034    .0025    .0014   0.0000

           1  HV        .0068    .0057    .0031    .0030    .0014   0.0000
                        .0019    .0017    .0013    .0013    .0008   0.0000

           1  LS        .0048    .0049    .0037    .0023    .0012   0.0000
                        .0016    .0016    .0014    .0011    .0008   0.0000

           1  HV+LS     .0019    .0018    .0010    .0010    .0003   0.0000
                        .0010    .0010    .0007    .0007    .0004   0.0000

VEHICLES   2  N         .0259    .0236    .0289    .0324    .0339    .0365
                        .0036    .0035    .0038    .0041    .0041    .0043

MOVING     2  HV        .0077    .0102    .0089    .0074    .0064    .0041
                        .0022    .0023    .0021    .0020    .0018    .0015

TOWARD     2  LS        .0012    .0042    .0060    .0083    .0098    .0100
                        .0008    .0015    .0018    .0021    .0023    .0023

MEDIAN     2  HV+LS     .0011    .0020    .0023    .0025    .0036    .0025
                        .0008    .0010    .0011    .0011    .0014    .0011

           3  N        0.0000    .0082    .0147    .0208    .0253    .0306
                       0.0000    .0021    .0029    .0033    .0036    .0039

           3  HV       0.0000    .0008    .0025    .0036    .0046    .0060
                       0.0000    .0007    .0011    .0014    .0016    .0018

           3  LS       0.0000    .0004    .0014    .0012    .0037    .0044
                       0.0000    .0005    .0008    .0008    .0014    .0015

           3  HV+LS    0.0000    .0003    .0003    .0004    .0008    .0008
                       0.0000    .0004    .0004    .0005    .0007    .0007
```

Before
%



After
%



```
TOTALS      .0568    .0449    .0298    .0183    .0067   0.0000
LANE 1      .0053    .0047    .0039    .0031    .0019   0.0000

TOTALS      .0380    .0401    .0462    .0505    .0537    .0530
LANE 2      .0044    .0045    .0048    .0050    .0052    .0051

TOTALS     0.0000    .0097    .0188    .0259    .0344    .0418
LANE 3     0.0000    .0022    .0031    .0036    .0042    .0046
```

There are some significant differences between the proportions in the Before and After phases. These are a function of the decrease in through maneuvers already described. However, it can be seen that the patterns of movement are unchanged in the Before and After phases.

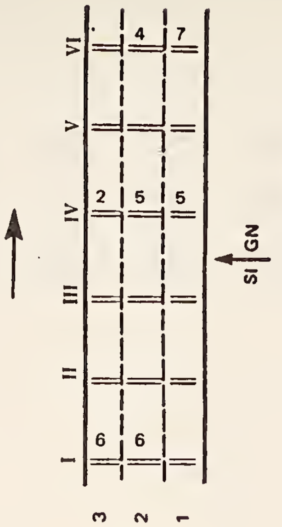
```
                   INTERCHANGE 18 WEST
                   ADVANCE (G-1) SIGN (BEFORE)
                   8/31/71
                   0930-1430

5550                       1       2       3       4       5       6

          1 N          .0569   .0456   .0324   .0200   .0092  0.0000
                       .0061   .0055   .0047   .0037   .0025  0.0000

          1 HV         .0054   .0045   .0045   .0020   .0013  0.0000
                       .0019   .0018   .0018   .0012   .0009  0.0000

          1 LS         .0106   .0070   .0058   .0050   .0034  0.0000
                       .0027   .0022   .0020   .0019   .0015  0.0000

          1 HV+LS      .0016   .0016   .0011   .0005   .0002  0.0000
                       .0011   .0011   .0009   .0006   .0004  0.0000

VEHICLES  2 N          .0274   .0279   .0315   .0344   .0395   .0467
                       .0043   .0043   .0046   .0048   .0051   .0055

 MOVING   2 HV         .0067   .0072   .0058   .0072   .0056   .0047
                       .0021   .0022   .0020   .0022   .0020   .0018

 TOWARD   2 LS         .0029   .0045   .0054   .0086   .0101   .0112
                       .0014   .0018   .0019   .0024   .0026   .0028

 MEDIAN   2 HV+LS      .0013   .0013   .0027   .0023   .0016   .0016
                       .0009   .0009   .0014   .0013   .0011   .0011

          3 N         0.0000   .0115   .0211   .0274   .0357   .0398     TOTALS      .0746   .0587   .0438   .0276   .0141  0.0000
                      0.0000   .0028   .0038   .0043   .0049   .0051     LANE 1      .0069   .0062   .0054   .0043   .0031  0.0000

          3 HV        0.0000   .0005   .0013   .0016   .0023   .0038     TOTALS      .0382   .0409   .0454   .0526   .0568   .0641
                      0.0000   .0006   .0009   .0011   .0013   .0016     LANE 2      .0050   .0052   .0055   .0059   .0061   .0064

          3 LS        0.0000   .0009   .0013   .0025   .0036   .0047     TOTALS     0.0000   .0132   .0236   .0326   .0420   .0486
                      0.0000   .0008   .0009   .0013   .0016   .0018     LANE 3     0.0000   .0030   .0040   .0047   .0053   .0057

          3 HV+LS     0.0000   .0002  0.0000   .0011   .0004   .0004
                      0.0000   .0004  0.0000   .0009   .0005   .0005
```

INTERCHANGE 18 WEST
ADVANCE (G-1) SIGN (AFTER)
8/29/72
0930-1430

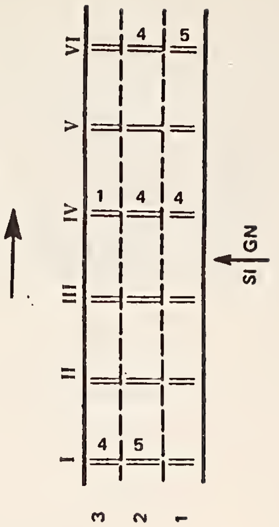
7323		1	2	3	4	5	6
	1 N	0.0000 0.0000	.0099 .0021	.0212 .0033	.0313 .0040	.0382 .0044	.0407 .0045
	1 HV	0.0000 0.0000	.0034 .0005	.0018 .0010	.0023 .0011	.0038 .0014	.0045 .0015
	1 LS	0.0000 0.0000	.0004 .0005	.0015 .0009	.0026 .0012	.0033 .0013	.0038 .0014
	1 HV+LS	0.0000 0.0000	.0001 .0003	.0008 .0007	.0011 .0008	.0014 .0008	.0026 .0012
VEHICLES	2 N	.0306 .0039	.0272 .0037	.0277 .0038	.0287 .0038	.0283 .0038	.0276 .0038
MOVING	2 HV	.0068 .0019	.0056 .0017	.0039 .0014	.0033 .0013	.0037 .0014	.0041 .0015
TOWARD	2 LS	.0069 .0019	.0075 .0020	.0051 .0016	.0048 .0016	.0038 .0014	.0048 .0016
SHOULDER	2 HV+LS	.0015 .0009	.0012 .0008	.0011 .0008	.0014 .0009	.0010 .0007	.0008 .0007
	3 N	.0283 .0038	.0257 .0036	.0168 .0029	.0078 .0020	.0034 .0013	0.0000 0.0000
	3 HV	.0025 .0011	.0022 .0011	.0022 .0011	.0015 .0009	.0004 .0005	0.0000 0.0000
	3 LS	.0111 .0024	.0081 .0020	.0057 .0017	.0040 .0014	.0014 .0008	0.0000 0.0000
	3 HV+LS	.0014 .0008	.0016 .0009	.0012 .0008	.0003 .0004	.0003 .0004	0.0000 0.0000

TOTALS LANE 1	0.0000 0.0000	.0098 .0023	.0253 .0036	.0373 .0043	.0467 .0048	.0516 .0051
TOTALS LANE 2	.0457 .0048	.0415 .0046	.0377 .0044	.0381 .0044	.0367 .0043	.0373 .0043
TOTALS LANE 3	.0432 .0047	.0376 .0044	.0259 .0036	.0135 .0026	.0055 .0017	0.0000 0.0000

Before
%



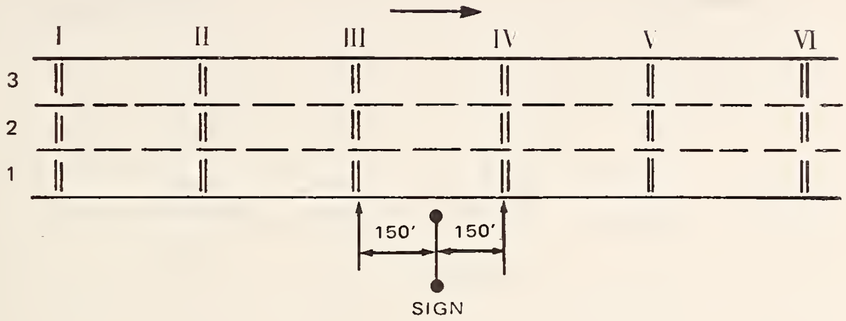
After
%



Once again, there are some significant differences between the proportions in the Before and After phases. These are a function of the decrease in preparatory maneuvers already described. As was the case for vehicles moving towards the median, the patterns of movement are unchanged in the After phase.

```
                         INTERCHANGE 18 WEST
                         ADVANCE (G-1) SIGN (BEFORE)
                         8/31/71
                         0930-1430

 5550                          1         2         3         4         5         6

              1 N         0.0000     .0132     .0290     .0398     .0523     .0589
                          0.0000     .0030     .0044     .0051     .0059     .0062

              1 HV        0.0000     .0004     .0020     .0027     .0041     .0056
                          0.0000     .0005     .0012     .0014     .0017     .0020

              1 LS        0.0000     .0004     .0020     .0032     .0058     .0076
                          0.0000     .0005     .0012     .0015     .0020     .0023

              1 HV+LS     0.0000     .0002     .0007     .0007     .0005     .0011
                          0.0000     .0004     .0007     .0007     .0006     .0009

VEHICLES      2 N          .0468     .0445     .0387     .0404     .0355     .0341
                           .0056     .0054     .0051     .0052     .0049     .0048

 MOVING       2 HV         .0045     .0050     .0032     .0027     .0016     .0025
                           .0018     .0019     .0015     .0014     .0011     .0013

 TOWARD       2 LS         .0083     .0079     .0061     .0090     .0081     .0070
                           .0024     .0023     .0021     .0025     .0024     .0022

SHOULDER      2 HV+LS      .0018     .0009     .0002     .0011     .0004     .0005
                           .0011     .0008     .0004     .0009     .0005     .0006

              3 N          .0378     .0315     .0247     .0124     .0049    0.0000    TOTALS    0.0000     .0141     .0337     .0465     .0627     .0732
                           .0050     .0046     .0041     .0029     .0018    0.0000    LANE 1    0.0000     .0031     .0047     .0055     .0064     .0069

              3 HV         .0020     .0020     .0014     .0004     .0009    0.0000    TOTALS     .0614     .0584     .0483     .0532     .0456     .0441
                           .0012     .0012     .0010     .0005     .0008    0.0000    LANE 2     .0063     .0062     .0056     .0059     .0055     .0054

              3 LS         .0153     .0108     .0086     .0045     .0031    0.0000    TOTALS     .0559     .0449     .0353     .0177     .0090    0.0000
                           .0032     .0027     .0024     .0018     .0015    0.0000    LANE 3     .0060     .0054     .0049     .0035     .0025    0.0000

              3 HV+LS      .0007     .0005     .0005     .0004     .0002    0.0000
                           .0007     .0006     .0006     .0005     .0004    0.0000
```

Advance (G-2) Location. Instrumentation was the same as that at the exit direction location and is diagrammed below.



There was little difference in the percent volume in each lane as vehicles proceeded through the array from Traps 1 to 6. The range in percentage mean hourly volume by vehicle type and lane as measured at Trap 6 across the four data collection days (two in the Before phase, two in the After phase) was:

	Total	Auto	Nonauto
Lane 1	37-40	35-38	54-74
Lane 2	41-43	42-45	23-28
Lane 3	17-21	18-22	3-18

As was the case at the exit direction sign, the majority of the traffic volume measured was located in Lanes 1 and 2. The preferred lane for nonauto traffic was Lane 1. The wide range in values for nonauto traffic was due to one day of data collection in the Before phase (October 4, 1971 in which proportionately more nonautos were found in Lane 3 and proportionately less in Lane 1 than on the other three data collection days.

As at the exit direction sign, vehicle speeds in all lanes increased as the tapeswitch array was traversed from Trap 1 to Trap 6. This occurred in all lanes and in both the Before and After data. The range in absolute mean speed at Traps 1 and 6 across the four data collection days was:

	Trap 1	Trap 6
Lane 1	47-49	51-52
Lane 2	51-54	57-58
Lane 3	49	55-62

Absolute mean speed data through the array were similar in the Before and After study.

Tables on the following pages present the proportions of vehicles performing various types of lane changes and meeting the criteria for speed difference, erratic maneuvers. and headway violations.

INTERCHANGE 18 WEST
ADVANCE (G-2) SIGN (BEFORE)
10/4/71
0930-1430

INTERCHANGE 18 WEST
ADVANCE (G-2) SIGN (AFTER)
9/25/72
0930-1430

		AUTOS	AUTOS		NONAUTOS	NONAUTOS		ALL	ALL	
		4531	5498		432	517		4963	6015	
1.	PREP. MANUEVERS	.12955 .00978	.07930 .00714	↓	.17361 .03572	.11412 .02741	↓	.13339 .00946	.08229 .00695	↓
2.	THROUGH MANUEVERS	.08652 .00819	.07385 .00691	↓	.06713 .02360	.04642 .01814	N.S.	.08483 .00775	.07149 .00651	↓
3.	OTHER LANE CHANGES	.06091 .00696	.06875 .00669	N.S.	.02778 .01550	.02708 .01399	N.S.	.05803 .00650	.06517 .00624	N.S.
4.	NO LANE CHANGES	.72302 .01303	.77810 .01098	↑	.73148 .04179	.81238 .03365	↑	.72376 .01244	.78105 .01045	↑
1.	SPEED DIFFERENCE	.16619 .01084	.19171 .01041	↑	.35648 .04517	.47969 .04306	↑	.18275 .01075	.21646 .01041	↑
2.	HEADWAY VIOLATION	.10792 .00903	.11441 .00841	N.S.	.05556 .02160	.04642 .01814	N.S.	.10336 .00847	.10856 .00786	N.S.
3.	DBL LANE CHANGES	.05076 .00639	.00928 .00253	↓	.04630 .01981	.00580 .00655	↓	.05037 .00608	.00898 .00238	↓
4.	1 + 2	.05164 .00644	.06948 .00672	↑	.06019 .02243	.06963 .02194	N.S.	.05239 .00620	.06949 .00643	↑
5.	2 + 3	.01015 .00292	.00273 .00138	↓	.00694 .00783	.00580 .00655	N.S.	.00987 .00275	.00299 .00138	↓
6.	1 + 3	.02670 .00469	.00618 .00207	↓	.07870 .02539	.00774 .00755	↓	.03123 .00484	.00632 .00200	↓
7.	1 + 2 + 3	.00662 .00236	.00309 .00147		.00694 .00783	0.00000 0.00000		.00665 .00226	.00283 .00134	
8.	NORMAL	.58000 .01437	.60313 .01293	↑	.38889 .04597	.38491 .04194	N.S.	.56337 .01380	.58437 .01245	↑

The data presented in this table for the paired Monday Before/After data collection days are best reviewed in conjunction with the data presented in the equivalent table for Tuesday (see the next page). Comparison of the tables shows that while there are many significant differences on Monday, the Tuesday data did not confirm them. It will be noted that a number of the 10/4/71 values are quite different from the same values on the other three data collection days. It will also be remembered that the proportions of nonautos traversing the array in Lanes 1 and 3 were quite different on 10/4/71. Whether this is basic to the differences shown in the table above is unknown. It would seem best to place little weight on the 10/4/71 data and the comparisons in this table.

INTERCHANGE 18 WEST
ADVANCE (G-2) SIGN (BEFORE)
10/5/71
0930-1430

INTERCHANGE 18 WEST
ADVANCE (G-2) SIGN (AFTER)
9/26/72
0930-1430

		AUTOS	AUTOS		NONAUTOS	NONAUTOS		ALL	ALL	
		4381	5695		333	535		4714	6230	
1.	PREP. MANUEVERS	.07647 .00787	.07392 .00680	N.S.	.07808 .02882	.10467 .02594	N.S.	.07658 .00759	.07657 .00660	N.S.
2.	THROUGH MANUEVERS	.08126 .00809	.08060 .00707	N.S.	.03003 .01833	.04860 .01822	N.S.	.07764 .00764	.07785 .00665	N.S.
3.	OTHER LANE CHANGES	.06642 .00737	.07515 .00685	N.S.	.01802 .01429	.02430 .01305	N.S.	.06300 .00694	.07079 .00637	N.S.
4.	NO LANE CHANGES	.77585 .01235	.77032 .01092	N.S.	.87387 .03566	.82243 .03238	↑	.78277 .01177	.77480 .01037	N.S.
1.	SPEED DIFFERENCE	.13490 .01012	.19192 .01023	↓	.36036 .05157	.49346 .04237	↓	.15083 .01022	.21782 .01025	↓
2.	HEADWAY VIOLATION	.11459 .00943	.12186 .00850	N.S.	.07207 .02778	.05607 .01950	N.S.	.11158 .00839	.11621 .00796	N.S.
3.	DBL LANE CHANGES	.00753 .00256	.00632 .00206	N.S.	.00601 .00830	0.00000 0.00000		.00742 .00245	.00578 .00188	N.S.
4.	1 + 2	.04725 .00628	.06778 .00653	↓	.03003 .01833	.07664 .02254	↓	.04603 .00598	.06854 .00627	↓
5.	2 + 3	.00320 .00167	.00299 .00142	N.S.	0.00000 0.00000	.00187 .00366		.00297 .00155	.00289 .00133	N.S.
6.	1 + 3	.00502 .00209	.00790 .00230	N.S.	.00300 .00588	.00187 .00366	N.S.	.00488 .00199	.00738 .00213	N.S.
7.	1 + 2 + 3	.00183 .00126	.00404 .00165	↓	0.00000 0.00000	0.00000 0.00000		.00170 .00118	.00369 .00151	↓
8.	NORMAL	.68569 .01375	.59719 .01274	↑	.52853 .05362	.37009 .04091	↑	.67459 .01338	.57769 .01227	↑

The Tuesday data show no significant difference in vehicular maneuvers between the Before and After phases. With regard to other criteria, the proportion of vehicles falling into the normal category (meeting none of criteria 1 through 7 below the dashed line) is significantly increased in the After phase. The increase is attributable to a reduction in the proportion of vehicles traveling at least 5 mph less than the mean speed for all vehicles measured at each trap.

INTERCHANGE 18 WEST
ADVANCE (G-2) SIGN (BEFORE)
10/5/71
0930-1430

INTERCHANGE 18 WEST
ADVANCE (G-2) SIGN (AFTER)
9/26/72
0930-1430

		LOCAL	LOCAL		FOREIGN	FOREIGN		ALL	ALL	
		2569	3289		377	437		2946	3726	
1.	PREP. MANUEVERS	.07707 .01031	.07540 .00902	N.S.	.05040 .02208	.07780 .02511	N.S.	.07366 .00943	.07568 .00849	N.S.
2.	THROUGH MANUEVERS	.07941 .01046	.07875 .00921	N.S.	.07[illegible]2 .02690	.04805 .02005	N.S.	.07909 .00975	.07515 .00847	N.S.
3.	OTHER LANE CHANGES	.06851 .00977	.06841 .00863	N.S.	.04244 .02035	.05492 .02136	N.S.	.06517 .00891	.06683 .00802	N.S.
4.	NO LANE CHANGES	.77501 .01615	.77744 .01422	N.S.	.83024 .03790	.81922 .03608	N.S.	.78208 .01491	.78234 .01325	N.S.
1.	SPEED DIFFERENCE	.14052 .01344	.20736 .01386	↓	.19629 .04009	.26316 .04129	↓	.14766 .01281	.21390 .01317	↓
2.	HEADWAY VIOLATION	.12223 .01267	.11827 .01104	N.S.	.06631 .02512	.08696 .02642	N.S.	.11507 .01152	.11460 .01023	N.S.
3.	DBL LANE CHANGES	.00856 .00356	.00791 .00303	N.S.	.00531 .00733	.00229 .00448	N.S.	.00815 .00325	.00725 .00272	N.S.
4.	1 + 2	.04710 .00819	.06963 .00870	↓	.03183 .01772	.06178 .02257	↓	.04515 .00750	.06871 .00812	↓
5.	2 + 3	.00272 .00202	.00182 .00146	N.S.	.00265 .00519	.00229 .00448	N.S.	.00272 .00188	.00188 .00139	N.S.
6.	1 + 3	.00428 .00252	.00851 .00314	↓	.00796 .00897	.00229 .00449	N.S.	.00475 .00248	.00778 .00282	N.S.
7.	1 + 2 + 3	.00195 .00170	.00456 .00230	N.S.	0.00000 0.00000	.00229 .00448		.00170 .00149	.00429 .00210	↓
8.	NORMAL	.67264 .01815	.58194 .01686	↑	.68966 .04670	.57895 .04629	↑	.67481 .01692	.58159 .01584	↑

The local and foreign subpopulations reflect the data for all vehicles collected on the same day (see preceding table).

As shown in the preceding tables, the proportions of vehicles not changing lanes was roughly 80 percent. The distribution of these vehicles across the three lanes instrumented in the Before and After phases (the upper number is the proportion and the lower number the 95 percent confidence limit) was:

	Monday		Tuesday	
	10/4/71	9/25/72	10/5/71	9/26/72
Lane 1	.2609 .0122	.3185 .0118	.3303 .0134	.3034 .0114
Lane 2	.3069 .0128	.2936 .0115	.3063 .0132	.2857 .0112
Lane 3	.1243 .0092	.1332 .0086	.1103 .0089	.1424 .0087

For the Monday data, the proportions in Lane 1 are significantly different but those in Lanes 2 and 3 are not. For the Tuesday data, proportions in all lanes are significantly different. Thus, although no significant difference was found for the proportions of all vehicles not changing lanes, the vehicles were distributed differently in the Before and After phases. However, as has been seen, there was little impact in behavior at the gore at this interchange.

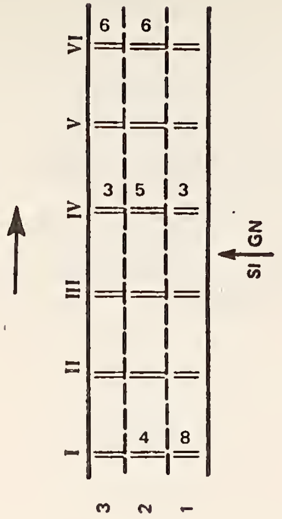
The proportion of vehicles moving in both directions was:

	Monday		Tuesday	
	10/4/71	9/25/72	10/5/71	9/26/72
Vehicles Changing Lanes In Both Directions	.0526 .0062	.0288 .0042	.0231 .0043	.0241 .0038

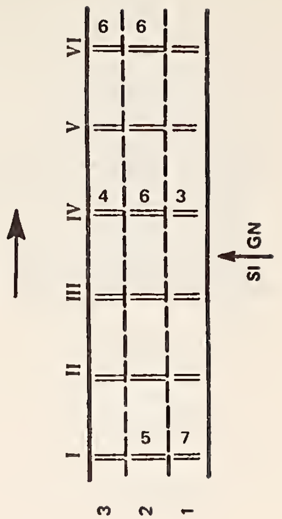
The Monday data are significantly different but the Tuesday data are not. Once again, the October 4, 1971 data appears quite different from the data collected on the other three days, perhaps because of the impact of the changed distribution of nonautos.

```
INTERCHANGE 18 WEST
ADVANCE (G-2) SIGN (AFTER)
9/25/72
0930-1430

6015                     1        2        3        4        5        6

             1 N       .0554    .0490    .0291    .0200    .0073   0.0000
                       .0058    .0055    .0042    .0035    .0022   0.0000

             1 HV      .0063    .0060    .0030    .0030    .0015   0.0000
                       .0020    .0019    .0014    .0014    .0010   0.0000

             1 LS      .0068    .0055    .0040    .0028    .0010   0.0000
                       .0021    .0019    .0016    .0013    .0008   0.0000

             1 HV+LS   .0023    .0013    .0015    .0013    .0002   0.0000
                       .0012    .0009    .0010    .0009    .0003   0.0000

VEHICLES     2 N       .0371    .0344    .0394    .0399    .0449    .0447
                       .0048    .0046    .0049    .0049    .0052    .0052

MOVING       2 HV      .0116    .0100    .0071    .0096    .0100    .0050
                       .0027    .0025    .0021    .0025    .0025    .0018

TOWARD       2 LS      .0017    .0028    .0071    .0065    .0091    .0116
                       .0010    .0013    .0021    .0020    .0024    .0027

MEDIAN       2 HV+LS   .0027    .0032    .0027    .0018    .0023    .0020
                       .0013    .0014    .0013    .0011    .0012    .0011

             3 N      0.0000    .0105    .0258    .0333    .0404    .0487
                      0.0000    .0026    .0040    .0045    .0050    .0054

             3 HV     0.0000    .0007    .0027    .0028    .0037    .0050
                      0.0000    .0007    .0013    .0013    .0015    .0018

             3 LS     0.0000    .0003    .0015    .0027    .0033    .0052
                      0.0000    .0005    .0010    .0013    .0015    .0018

             3 HV+LS  0.0000    .0002   0.0000    .0002    .0002    .0017
                      0.0000    .0003   0.0000    .0003    .0003    .0010
```

Before
%



After
%



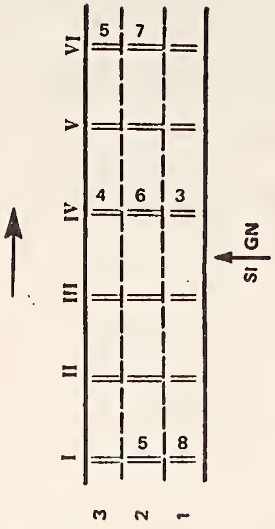
```
TOTALS     .0708    .0618    .0376    .0271    .0100   0.0000
LANE 1     .0065    .0061    .0048    .0041    .0025   0.0000

TOTALS     .0530    .0504    .0564    .0579    .0663    .0633
LANE 2     .0057    .0055    .0058    .0059    .0063    .0062

TOTALS    0.0000    .0116    .0299    .0389    .0475    .0605
LANE 3    0.0000    .0027    .0043    .0049    .0054    .0060
```

Although the patterns are similar, there are significant differences in the proportions between the Before and After phase when lane placement of vehicles moving towards the median are compared. Once again the differences are attributable to the 10/4/71 data (see the next page and compare the small table on that page to the same table on the following two pages and to the table on this page).

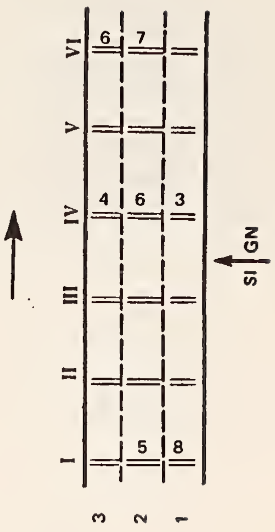
```
                INTERCHANGE 18 WEST
                ADVANCE (G-2) SIGN (BEFORE)
                10/4/71
                0930-1430

4963                    1       2       3       4       5       6

          1 N       .0655   .0554   .0361   .0250   .0119  0.0000
                    .0069   .0064   .0052   .0043   .0030  0.0000

          1 HV      .0071   .0056   .0032   .0042   .0010  0.0000
                    .0023   .0021   .0016   .0018   .0009  0.0000

          1 LS      .0097   .0085   .0044   .0028   .0008  0.0000
                    .0027   .0025   .0018   .0015   .0008  0.0000

          1 HV+LS   .0008   .0012   .0006   .0014   .0004  0.0000
                    .0008   .0010   .0007   .0010   .0006  0.0000

VEHICLES  2 N       .0246   .0232   .0363   .0391   .0403   .0427
                    .0043   .0042   .0052   .0054   .0055   .0056

 MOVING   2 HV      .0075   .0060   .0093   .0077   .0066   .0060
                    .0024   .0022   .0027   .0024   .0023   .0022

 TOWARD   2 LS      .0016   .0034   .0046   .0040   .0066   .0064
                    .0011   .0016   .0019   .0018   .0023   .0022

 MEDIAN   2 HV+LS   .0016   .0012   .0012   .0006   .0012   .0016
                    .0011   .0010   .0010   .0007   .0010   .0011

          3 N      0.0000   .0127   .0206   .0298   .0415   .0510    TOTALS     .0830   .0707   .0443   .0334   .0141  0.0000
                   0.0000   .0031   .0039   .0047   .0055   .0061    LANE 1     .0077   .0071   .0057   .0050   .0033  0.0000

          3 HV     0.0000   .0010   .0008   .0024   .0030   .0030    TOTALS     .0353   .0339   .0514   .0514   .0548   .0568
                   0.0000   .0009   .0008   .0014   .0015   .0015    LANE 2     .0051   .0050   .0061   .0061   .0063   .0064

          3 LS     0.0000  0.0000   .0012   .0010   .0046   .0073    TOTALS    0.0000   .0137   .0226   .0334   .0494   .0615
                   0.0000  0.0000   .0010   .0009   .0019   .0024    LANE 3    0.0000   .0032   .0041   .0050   .0060   .0067

          3 HV+LS  0.0000  0.0000  0.0000   .0002   .0002   .0002
                   0.0000  0.0000  0.0000   .0004   .0004   .0004
```

```
INTERCHANGE 18 WEST
ADVANCE (G-2) SIGN (AFTER)
9/26/72
0930-1430

6230                        1        2        3        4        5        6

             1 N          .0597    .0494    .0283    .0196    .0077   0.0000
                          .0059    .0054    .0041    .0034    .0022   0.0000

             1 HV         .0063    .0075    .0050    .0039    .0021   0.0000
                          .0020    .0021    .0017    .0015    .0011   0.0000

             1 LS         .0077    .0061    .0040    .0032    .0006   0.0000
                          .0022    .0019    .0016    .0014    .0006   0.0000

             1 HV+LS      .0035    .0016    .0016    .0019    .0011   0.0000
                          .0015    .0010    .0010    .0011    .0008   0.0000

VEHICLES     2 N          .0326    .0350    .0416    .0446    .0461    .0482
                          .0044    .0046    .0050    .0051    .0052    .0053

MOVING       2 HV         .0138    .0128    .0096    .0095    .0098    .0047
                          .0029    .0028    .0024    .0024    .0024    .0017

TOWARD       2 LS         .0051    .0056    .0106    .0075    .0111    .0133
                          .0018    .0019    .0025    .0021    .0026    .0028

MEDIAN       2 HV+LS      .0018    .0013    .0022    .0029    .0029    .0030
                          .0010    .0009    .0012    .0013    .0013    .0014

             3 N         0.0000    .0098    .0242    .0319    .0413    .0502
                         0.0000    .0024    .0038    .0044    .0049    .0054

             3 HV        0.0000    .0008    .0024    .0029    .0035    .0039
                         0.0000    .0007    .0012    .0013    .0015    .0015

             3 LS        0.0000    .0003    .0010    .0021    .0035    .0059
                         0.0000    .0004    .0008    .0011    .0015    .0019

             3 HV+LS     0.0000    .0002   0.0000    .0005    .0008    .0013
                         0.0000    .0003   0.0000    .0005    .0007    .0009
```

Before
%



After
%

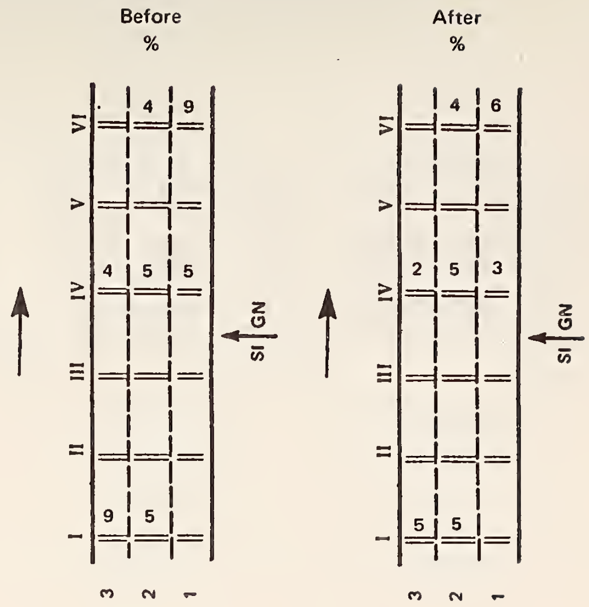


```
TOTALS      .0772    .0647    .0388    .0286    .0116   0.0000
LANE 1      .0066    .0061    .0048    .0041    .0027   0.0000

TOTALS      .0533    .0547    .0640    .0645    .0698    .0692
LANE 2      .0056    .0056    .0061    .0061    .0063    .0063

TOTALS     0.0000    .0111    .0276    .0374    .0491    .0613
LANE 3     0.0000    .0026    .0041    .0047    .0054    .0060
```

Most of the proportions are not significantly different for vehicles moving towards the median for the Tuesday paired data.

```
                    INTERCHANGE 18 WEST
                    ADVANCE (G-2) SIGN (BEFORE)
                    10/5/71
                    0930-1430

4714                      1       2       3       4       5       6

            1 N        .0634   .0552   .0299   .0214   .0091  0.0000
                       .0070   .0065   .0049   .0041   .0027  0.0000

            1 HV       .0053   .0066   .0057   .0055   .0030  0.0000
                       .0021   .0023   .0022   .0021   .0016  0.0000

            1 LS       .0055   .0055   .0036   .0025   .0008  0.0000
                       .0021   .0021   .0017   .0014   .0008  0.0000

            1 HV+LS    .0023   .0015   .0015   .0013   .0011  0.0000
                       .0014   .0011   .0011   .0010   .0009  0.0000

VEHICLES    2 N        .0329   .0284   .0416   .0433   .0467   .0530
                       .0051   .0047   .0057   .0058   .0060   .0064

 MOVING     2 HV       .0121   .0091   .0089   .0078   .0076   .0051
                       .0031   .0027   .0027   .0025   .0025   .0020

 TOWARD     2 LS       .0025   .0021   .0038   .0047   .0074   .0106
                       .0014   .0013   .0018   .0019   .0025   .0029

 MEDIAN     2 HV+LS    .0008   .0004   .0008   .0006   .0021   .0017
                       .0008   .0006   .0008   .0007   .0013   .0012

            3 N       0.0000   .0146   .0274   .0333   .0416   .0465   TOTALS     .0766   .0687   .0407   .0308   .0140  0.0000
                      0.0000   .0034   .0047   .0051   .0057   .0060   LANE 1     .0076   .0072   .0056   .0049   .0034  0.0000

            3 HV      0.0000   .0011   .0008   .0023   .0032   .0042   TOTALS     .0484   .0401   .0552   .0564   .0639   .0704
                      0.0000   .0009   .0008   .0014   .0016   .0019   LANE 2     .0061   .0056   .0065   .0066   .0070   .0073

            3 LS      0.0000   .0004   .0008   .0019   .0021   .0034   TOTALS    0.0000   .0161   .0291   .0378   .0471   .0545
                      0.0000   .0006   .0008   .0012   .0013   .0017   LANE 3    0.0000   .0036   .0048   .0054   .0060   .0065

            3 HV+LS   0.0000  0.0000  0.0000   .0002   .0002   .0004
                      0.0000  0.0000  0.0000   .0004   .0004   .0006
```

```
               INTERCHANGE 18 WEST
               ADVANCE (G-2) SIGN (AFTER).
               9/25/72
               0930-1430

6015                     1        2        3        4        5        6

           1 N       0.0000    .0071    .0140    .0264    .0389    .0524
                     0.0000    .0021    .0030    .0041    .0049    .0056

           1 HV      0.0000    .0002   0.0000    .0013    .0028    .0047
                     0.0000    .0003   0.0000    .0009    .0013    .0017

           1 LS      0.0000    .0012    .0025    .0040    .0052    .0073
                     0.0000    .0009    .0013    .0016    .0018    .0022

           1 HV+LS   0.0000   0.0000    .0002    .0008    .0007    .0005
                     0.0000   0.0000    .0003    .0007    .0007    .0006

VEHICLES   2 N        .0372    .0367    .0382    .0392    .0351    .0263
                      .0048    .0048    .0048    .0049    .0046    .0040

 MOVING    2 HV       .0052    .0065    .0058    .0040    .0028    .0025
                      .0018    .0020    .0019    .0016    .0013    .0013

 TOWARD    2 LS       .0068    .0120    .0120    .0083    .0086    .0083
                      .0021    .0027    .0027    .0023    .0023    .0023

SHOULDER   2 HV+LS    .0008    .0005    .0012    .0005    .0002    .0002
                      .0007    .0006    .0009    .0006    .0003    .0003

           3 N        .0313    .0224    .0165    .0101    .0033   0.0000
                      .0044    .0037    .0032    .0025    .0015   0.0000

           3 HV       .0030    .0023    .0015    .0007    .0003   0.0000
                      .0014    .0012    .0010    .0007    .0005   0.0000

           3 LS       .0160    .0125    .0101    .0060    .0035   0.0000
                      .0032    .0028    .0025    .0019    .0015   0.0000

           3 HV+LS    .0018    .0007    .0002    .0007    .0007   0.0000
                      .0011    .0007    .0003    .0007    .0007   0.0000
```

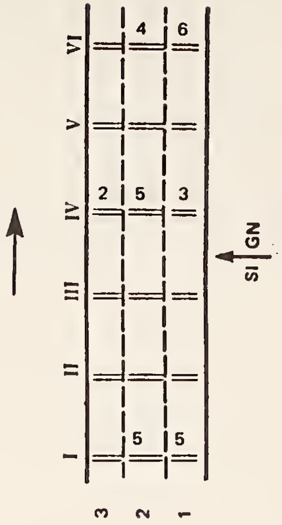


```
TOTALS     0.0000    .0085    .0166    .0326    .0475    .0648
LANE 1     0.0000    .0023    .0032    .0045    .0054    .0062

TOTALS      .0500    .0557    .0572    .0520    .0467    .0372
LANE 2      .0055    .0058    .0059    .0056    .0053    .0048

TOTALS      .0520    .0379    .0283    .0175    .0078   0.0000
LANE 3      .0056    .0048    .0042    .0033    .0022   0.0000
```

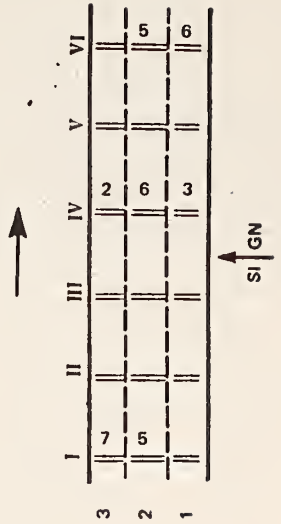
For the Monday paired data, the distribution of proportions shows some significant differences for vehicles moving towards the shoulder when the Before and After are compared. The illustration above indicates that the pattern of movement of the Monday Before data is different from the Monday After data and the Tuesday data.

```
                    INTERCHANGE 18 WEST
                    ADVANCE (G-2) SIGN (BEFORE)
                    10/4/71
                    0930-1430

4963                        1       2       3       4       5       6

          1 N          0.0000   .0071   .0149   .0371   .0574   .0766
                       0.0000   .0023   .0034   .0053   .0065   .0074

          1 HV         0.0000   .0004   .0006   .0028   .0032   .0058
                       0.0000   .0006   .0007   .0015   .0016   .0021

          1 LS         0.0000   .0010   .0018   .0058   .0048   .0083
                       0.0000   .0009   .0012   .0021   .0019   .0025

          1 HV+LS      0.0000   .0002  0.0000   .0004   .0008   .0014
                       0.0000   .0004  0.0000   .0006   .0008   .0010

VEHICLES  2 N            .0355   .0357   .0447   .0387   .0373   .0318
                         .0051   .0052   .0058   .0054   .0053   .0049

 MOVING   2 HV           .0052   .0052   .0052   .0048   .0046   .0014
                         .0020   .0020   .0020   .0019   .0019   .0010

 TOWARD   2 LS           .0062   .0066   .0115   .0103   .0109   .0109
                         .0022   .0023   .0030   .0028   .0029   .0029

SHOULDER  2 HV+LS        .0012   .0010   .0008   .0010   .0004   .0008
                         .0010   .0009   .0008   .0009   .0006   .0008

          3 N            .0669   .0635   .0419   .0292   .0103  0.0000   TOTALS   0.0000   .0087   .0173   .0461   .0663   .0921
                         .0070   .0068   .0056   .0047   .0028  0.0000   LANE 1   0.0000   .0026   .0036   .0058   .0069   .0080

          3 HV           .0044   .0032   .0022   .0018  0.0000  0.0000   TOTALS    .0482   .0486   .0623   .0548   .0532   .0449
                         .0018   .0016   .0013   .0012  0.0000  0.0000   LANE 2    .0060   .0060   .0067   .0063   .0062   .0058

          3 LS           .0161   .0117   .0121   .0044   .0062  0.0000   TOTALS    .0889   .0798   .0574   .0361   .0175  0.0000
                         .0035   .0030   .0030   .0018   .0022  0.0000   LANE 3    .0079   .0075   .0065   .0052   .0037  0.0000

          3 HV+LS        .0014   .0014   .0012   .0006   .0010  0.0000
                         .0010   .0010   .0010   .0007   .0009  0.0000
                    INTERCHANGE 18 WEST
                    ADVANCE (G-2) SIGN (AFTER)
                    9/26/72
                    0930-1430

6230                        1        2        3        4        5        6

              1 N      0.0000    .0056    .0117    .0278    .0422    .0523
                       0.0000    .0019    .0027    .0041    .0050    .0055

              1 HV     0.0000    .0006    .0013    .0027    .0034    .0042
                       0.0000    .0006    .0009    .0013    .0014    .0016

              1 LS     0.0000    .0008    .0011    .0021    .0035    .0055
                       0.0000    .0007    .0008    .0011    .0015    .0018

              1 HV+LS  0.0000   0.0000   0.0000    .0003    .0005    .0013
                       0.0000   0.0000   0.0000    .0004    .0005    .0009

VEHICLES      2 N       .0326    .0406    .0435    .0414    .0382    .0358
                        .0044    .0049    .0051    .0049    .0048    .0046

MOVING        2 HV      .0051    .0059    .0048    .0045    .0035    .0026
                        .0018    .0019    .0017    .0017    .0015    .0013

TOWARD        2 LS      .0083    .0124    .0144    .0108    .0108    .0116
                        .0023    .0027    .0030    .0026    .0026    .0027

SHOULDER      2 HV+LS   .0016    .0013    .0013    .0018    .0010    .0008
                        .0010    .0009    .0009    .0010    .0008    .0007

              3 N       .0393    .0273    .0205    .0135    .0058   0.0000
                        .0048    .0040    .0035    .0029    .0019   0.0000

              3 HV      .0027    .0018    .0021    .0006    .0005   0.0000
                        .0013    .0010    .0011    .0006    .0005   0.0000

              3 LS      .0218    .0161    .0122    .0079    .0047   0.0000
                        .0036    .0031    .0027    .0022    .0017   0.0000

              3 HV+LS   .0024    .0016    .0010    .0006   0.0000   0.0000
                        .0012    .0010    .0008    .0006   0.0000   0.0000
```

Before
%



After
%



```
TOTALS    0.0000    .0071    .0141    .0329    .0496    .0632
LANE 1    0.0000    .0021    .0029    .0044    .0054    .0060

TOTALS     .0477    .0602    .0640    .0584    .0535    .0507
LANE 2     .0053    .0059    .0061    .0058    .0056    .0054

TOTALS     .0663    .0467    .0358    .0226    .0109   0.0000
LANE 3     .0062    .0052    .0046    .0037    .0026   0.0000
```

For the Tuesday paired data, the patterns of movement are similar in the Before and After phases.

```
                 INTERCHANGE 18 WEST
                 ADVANCE (G-2) SIGN (BEFORE)
                 10/5/71
                 0930-1430

4714                       1       2       3       4       5       6

            1 N       0.0000   .0091   .0138   .0308   .0431   .0558
                      0.0000   .0027   .0033   .0049   .0058   .0066

            1 HV      0.0000   .0006   .0004   .0015   .0025   .0036
                      0.0000   .0007   .0006   .0011   .0014   .0017

            1 LS      0.0000   .0006   .0011   .0006   .0023   .0034
                      0.0000   .0007   .0009   .0007   .0014   .0017

            1 HV+LS   0.0000  0.0000  0.0000  0.0000  0.0000   .0008
                      0.0000  0.0000  0.0000  0.0000  0.0000   .0008

VEHICLES    2 N        .0401   .0386   .0424   .0403   .0354   .0329
                       .0056   .0055   .0058   .0056   .0053   .0051

 MOVING     2 HV       .0055   .0051   .0049   .0021   .0023   .0025
                       .0021   .0020   .0020   .0013   .0014   .0014

 TOWARD     2 LS       .0066   .0066   .0074   .0076   .0070   .0049
                       .0023   .0023   .0025   .0025   .0024   .0020

SHOULDER    2 HV+LS    .0008   .0006   .0002   .0004   .0015   .0011
                       .0008   .0007   .0004   .0006   .0011   .0009

            3 N        .0365   .0280   .0225   .0155   .0070  0.0000    TOTALS   0.0000   .0104   .0153   .0329   .0479   .0636
                       .0054   .0047   .0042   .0035   .0024  0.0000    LANE 1   0.0000   .0029   .0035   .0051   .0061   .0070

            3 HV       .0021   .0028   .0015   .0006   .0004  0.0000    TOTALS    .0530   .0509   .0549   .0505   .0462   .0414
                       .0013   .0015   .0011   .0007   .0006  0.0000    LANE 2    .0064   .0063   .0065   .0063   .0060   .0057

            3 LS       .0121   .0119   .0104   .0053   .0032  0.0000    TOTALS    .0520   .0437   .0348   .0216   .0108  0.0000
                       .0031   .0031   .0029   .0021   .0016  0.0000    LANE 3    .0063   .0058   .0052   .0042   .0030  0.0000

            3 HV+LS    .0013   .0011   .0004   .0002   .0002  0.0000
                       .0010   .0009   .0006   .000[illegible]   .0004  0.0000
```

Summary. At this interchange, the signs remained conventional throughout the study. The interchange served as a control for the other interchanges where the conventional signs were replaced by diagrammatics between the Before and After studies.

At the gore, no consistent significant differences in vehicles traveling at least 5 mph less than the mean speed for all vehicles at each trap, headway violations, hazardous maneuvers or combinations of these were found when data collected in the Before and After phases were compared. Lane usage by exiting and through vehicle subpopulations was also unchanged.

Conclusions at the exit direction sign are based on one pair of matched days because weather prevented data collection on one day in the After phase. In the vicinity of the exit direction sign, significant reductions were found in preparatory maneuvers, through maneuvers and double lane changes while there was a significant increase in the proportion of vehicles performing no maneuvers in the After phase. Because a significant deterioration in performance at the gore was not found, however, the changes in maneuvering at the exit direction location mean little.

Also at the exit direction location, the incidence of speed differences and headway violations were unchanged in the After phase. Lane placement data indicated that patterns of movement did not change in the one year time span between data collection periods.

At the advance sign location, data from one pair of matched days showed no significant differences in vehicular maneuvers and in most other criteria. However, there was a significant reduction in the proportion of vehicles meeting the speed difference criterion which was reflected in an increase in vehicles classified as normal. Lane placement data indicated patterns of movement remained unchanged in the After phase. Some differences were found for the other pair of matched days at this location. A possible explanation is the change in lane usage of nonauto traffic compared to all other days. Because this one day seemed somewhat different from all other days, it was given relatively little weight.

On balance, a detailed analysis of data collected at the gore, exit direction and advance sign locations of the control interchange indicates that traffic behavior remained essentially unchanged at this interchange from one year to the next.

Summary of TES Results on Speed Differences, Headway Violations and Hazardous Maneuvers at Gore Areas in the Before/After Study

For reference, the following tables summarize TES data on speed differences, headway violations, hazardous maneuvers and various combinations of these at gore locations.

The first table shows each of the measures and whether significant increases, decreases or no significant differences were found for the population of vehicles as a whole on each pair of matched days.

GORE	16S		17N		18E		18W		Democ.	
	Day Pair		Day Pair		Day Pair		Day Pair		Day Pair	
Measure	1	2	1	2	1	2	1	2	1	2
1. Speed Difference	↓	↓	↓	↓	N.S.	N.S.	N.S.	N.S.		↓
2. Headway Violation	↑	N.S.	↑	↓	N.S.	N.S.	↓	N.S.		N.S.
3. Hazardous Maneuvers	↑	N.S.	↓	↓	↓	↓	N.S.	N.S.		↓
4. 1 + 2	N.S.	N.S.	N.S.	↓	N.S.	N.S.	N.S.	↑		N.S.
5. 2 + 3	N.S.	↑	↓	↓	↓	N.S.	N.S.	↑		↓
6. 1 + 3	↓	N.S.	↓	↓	N.S.	↓	N.S.	N.S.		↓
7. 1 + 2 + 3	N.S.	N.S.	↓	↓	N.S.	N.S.	N.S.	N.S.		↓
8. Normal	N.S.	↑	↑	↑	N.S.	N.S.	N.S.	N.S.		↑
9. Dbl. Lane Changes	N.S.	N.S.	↓	↓	↓	N.S.	↓	N.S.		↓

↑ = increase in the After phase significant at the .05 level or better

↓ = decrease in the After phase significant at the .05 level or better

N.S. = no significant difference in the Before and After phases

As can be seen, significant differences are most frequent and most consistent across the two sets of paired Before/After data collection days at Interchange 17 North. This is the left exit major fork interchange. With the exception of an increase in headway violations on one day, the direction of all changes indicates improved performance under the diagrammatic signing condition.

Fewest significant differences are found at the gore of the control interchange, 18 West, and none are consistent across days.

The total incidence of hazardous maneuvers at gore areas can be found by summing the proportions of vehicles opposite the measures numbered 3, 5, 6 and 7 in the tables which have been presented. As shown in the next table, it is clear that the greatest change has been effected at Interchange 17 North. For example, 17 percent of vehicles coded as foreign in the Before

Total Hazardous Maneuvers at Gores

Inter-		Autos		Nonautos		All		Local		Foreign		All	
Change	Day	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
16S	1	.03163	.03401	.01307	.00950	.02960	.03100	.03115	.02846	.02388	.02471	.03032	.02815
	2	.03508	.03430	.01908	.03663	.03340	.03458						
17N	1	.12681	.04519	.09929	.04094	.12449	.04488	.12667	.04232	.16911	.06956	.1300	.04450
	2	.07815	.04564	.06415	.02880	.07712	.04450						
18E	1	.08503	.06242	.26612	.12738	.10031	.06859	.10670	.07545	.14793	.05835	.11050	.07298
	2	.08572	.07121	.28977	.16927	.10454	.08033						
18W	1	.05025	.05319	.03483	.06637	.04894	.05467	.05349	.05767	.05101	.04620	.05316	.05616
	2	.05627	.05254	.06369	.13014	.05694	.05989						
Democ	1	Before Phase Sample Limited						.03114	.01288	.01941	.01963	.03013	.01401
	2	.03144	.01365	.02051	.01160	.03054	.01348						

phase performed such maneuvers whereas only seven percent did in the After phase. Interchange 18 East, the simple diamond with one right exit, also shows improvement particularly for the nonauto and foreign vehicle subpopulations. At the first exit from the cloverleaf, Democracy Boulevard, some benefit is also seen. However, only one day of data are presented because the Before phase sample on the other day was very limited. At 16 South, and at the control interchange, 18 West, little difference is found.

For comparison, the following table presents the total speed differences at the same gore locations. These are obtained by summing the proportions of vehicles opposite the measures labelled 1, 4, 6 and 7 in the tables which have been presented.

It is clear that consistent reductions in the proportion of all vehicles and all subpopulations traveling at speeds at least 5 mph below the mean speed for all vehicles are found only at Interchange 17 North and at the first gore of Democracy Boulevard. Results at Democracy Boulevard are based on only one pair of matched days, however.

The speed differences and hazardous maneuver data tend to parallel each other; that is, a reduction in one measure in the After phase tends to be accompanied by a reduction in the other. The main exception is in 18 East where hazardous maneuvers. particularly of the nonauto and foreign vehicles, were sizeably reduced in the After phase. However, the proportion of nonauto and foreign vehicles meeting the speed difference criterion increased in the After phase. The relationship between these measures should be further investigated.

Comment on TES Data Not Reported

Although TES data were collected at fourteen signing locations, it is reported only at eleven. The data collected by means of the backup system of time-lapse photography are reported at the other three locations. The sites where TES data were not used are Interchange 15 North at the gore and Interchange 16 North at the gore and at the exit direction sign. The reasons for inadequacy of the TES data are illuminating for future users of this system.

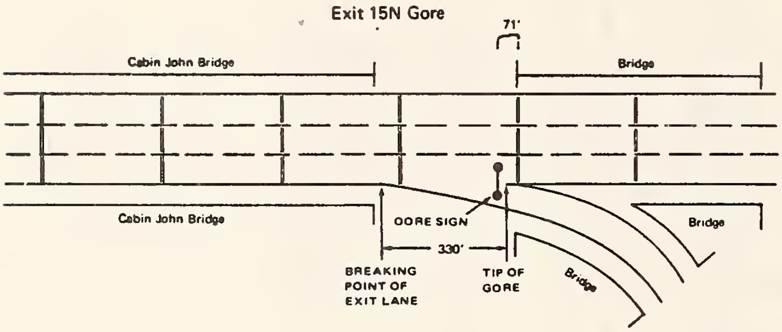
Basically, the problems with these data stem from unreliability of certain models of tapeswitch, particularly in suboptimal weather conditions such as heavy rain for long periods. Before phase data at Interchange 16 North at the exit direction location were collected in heavy and continuous rain with the model 131 tapeswitch. A high level of switch failures resulted.

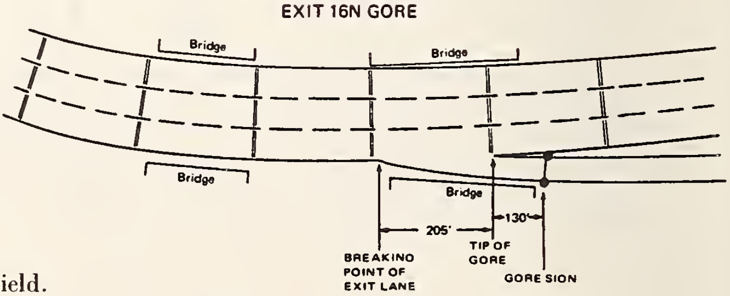
Total Speed Differences at Gores

Inter-		Autos		Nonautos		All		Local		Foreign		All	
Change	Day	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
16S	1	.32414	.36016	.41881	.38400	.33447	.31572	.34737	.32909	.30504	.28038	.34253	.32351
	2	.37334	.31278	.45946	.44283	.38243	.32735						
17N	1	.35106	.28321	.48226	.39961	.36205	.29158	.36068	.28375	.30319	.28405	.35576	.28378
	2	.32809	.27016	.45852	.38939	.33773	.27819						
18E	1	.26643	.25337	.49431	.49888	.28751	.27619	.28896	.29553	.23669	.27586	.28415	.29270
	2	.25979	.25814	.45968	.52017	.27667	.28303						
18W	1	25030	.24440	.56716	.57301	.27715	.28131	.28024	.27232	.23214	.30362	.27373	.27645
	2	.25159	.25221	.52123	.59817	.27597	.28497						
Democ	1	Before Phase Sample Limited						.29196	.25553	.29126	.26087	.29190	.25642
	2	.27549	.24672	.53759	.44487	.29679	.26336						

Although some switch failure can be accommodated by the redundancy[1] in the tapeswitch deployment configuration used, the failure rate at this site was too high. Only 60 percent of the vehicles could be tracked through three traps or more. Because of this unreliability, these data were discarded. More reliable switches are available and the reader is referred to Appendix A for further information.

The problem at the gores of Interchanges 15 North and 16 North was not weather but the deployment configuration of the tapeswitches, given their less than total reliability. At these sites, the three through lanes were instrumented and no switches were placed in the exit ramp. The reason was that at the time the best information on the characteristics of the software indicated that only three lanes of traffic could be handled by the system. Since the exit ramp would count as a lane, its instrumentation opposite switch pairs 5 and 6 meant sacrificing one lane of traffic for two pairs of switches. It was reasoned that if the exit ramp were not instrumented, exiting traffic could be obtained as vehicles leaving the array at Trap 4. This is feasible but only if the switches are highly reliable. Switch failure, even of pairs of switches, can be accommodated. However, means for checking the extrapolations in the form of positive data downstream from the failure should be available. The data collected with the above configurations did show reasonable percentages of exiting vehicles when compared to time-lapse data at the same location. For example, at 15 North both techniques showed about five percent of traffic exiting. However, it was felt that for the type of maneuver analysis being done in this study, such data could be misleading. Therefore, the time-lapse films were used at these two locations.





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[1] Refer to Appendix A, Troubleshooting in the Field.

Before/After Study—Questionnaire Analysis[1]

Data from the Before/After studies were analyzed in an attempt to isolate respondents' experiences of and sentiments toward the section of the Capital Beltway under consideration. The raw data from which these cross tabulations are made may be found in Appendix C. The actual questionnaire forms used are found in Appendix B. Cross tabulations were prepared and Chi-square tests applied to identify relationships between responses to a number of questions. For these purposes data across all classes of respondents (exit, thruput and selected) were combined. It was felt that the combined data more closely approximate the total population using I-495/I-70S as compared to those subpopulations exiting at a particular location or those who are through drivers.

The analyses can be grouped into four topical areas:

- Items related to the diagrammatic signs in particular
- Items related to reports of difficulty with the signs (Before/After data)
- Items related to information preferred on the signs (combined data)
- Items related to license plates (combined data).

Results are shown graphically and discussed below. The graphic presentations show both percentages and the absolute number of cases falling into the various classes. Combination of all respondents resulted in a potential data base of 396 for the Before stage and 395 for the After stage totaling 791 respondents. However, exclusion of blanks and indecipherable responses generally reduced the size of the data base.

Diagrammatic Signs

Data from the After study were analyzed separately in order to find motorists' experiences with diagrammatic signs and their preferences for sign types.

Personal Preference

Respondents were asked to indicate their personal choice between conventional and diagrammatic signs. Figure 20 shows these data. Ninety-three percent of those answering the question indicated they preferred diagrammatic signs while seven percent preferred conventional signing.

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[1] The questionnaire data collection procedure is described on Pages 4–3 through 4–5.

[2] Data reduction was accomplished by Margaret Forsythe and Gerald Vallette, and Gerald Vallette conducted the data analysis and prepared this section. Their contributions are gratefully acknowledged.

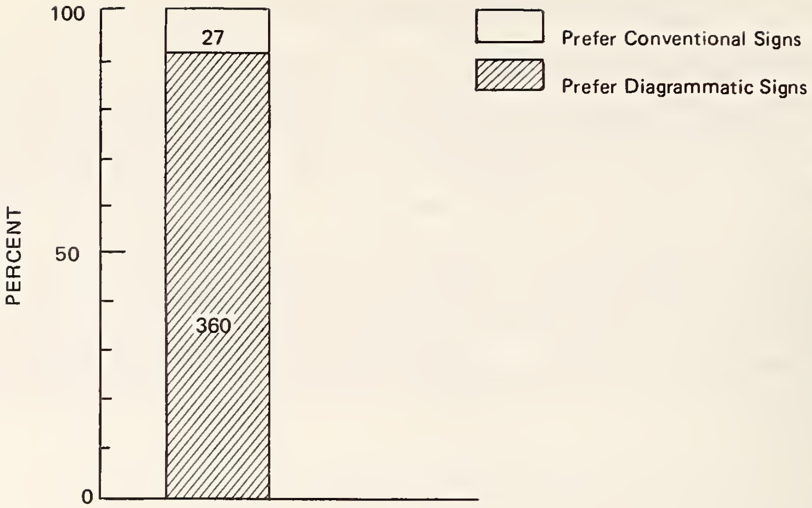

Figure 20. Which type of sign do you prefer?

Are Diagrammatic Signs Helpful

Respondents were also asked to indicate how much help they thought the diagrammatic signs were to the average motorist, i.e., everyone else besides themselves. Figure 21 shows that 93 percent thought that the diagrammatic signs were more helpful while five percent thought they were less helpful.

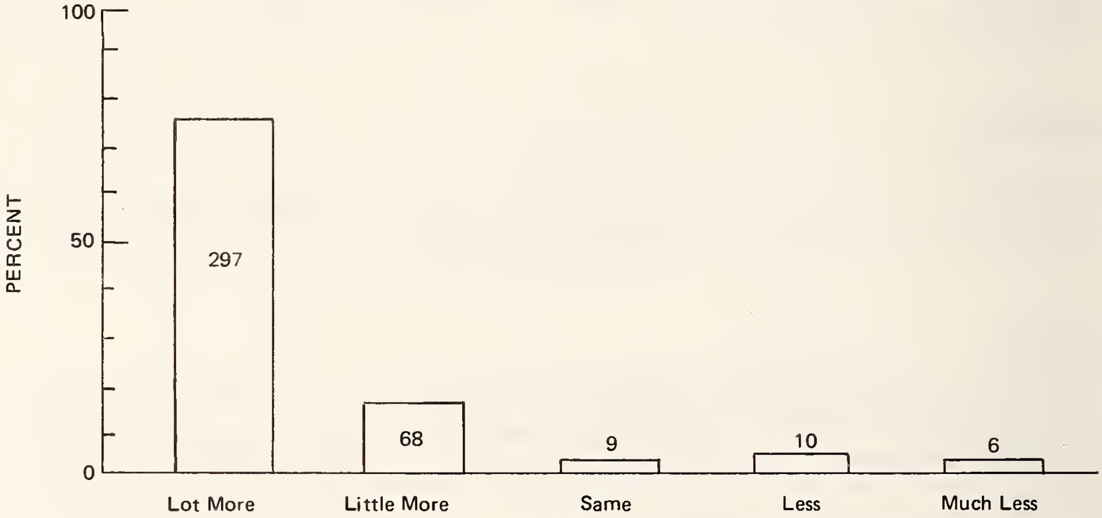

Figure 21. How much help are diagrammatic signs relative to conventional signs to the average motorist?

As may be expected, a cross tabulation of these two itmes, seen in Figure 22, is highly significant ($X^2 = 248.46$, df = 4, $p < .001$). It is not perfect, however, as there were a few respondents who, although they preferred one type of sign, indicated that most motorists were probably aided more by the other. Of these cases, most often the drivers felt the diagrammatic signs were more helpful to others but preferred conventional signing themselves. Of the seven cases in this category, two made comments that may be indicative of other persons' feelings. One said that while diagrammatic signs were probably better, she preferred conventional signing because she was "used to them." The other comment was that the diagrammatic signs would be more helpful "once (you are) accustomed to (them)."

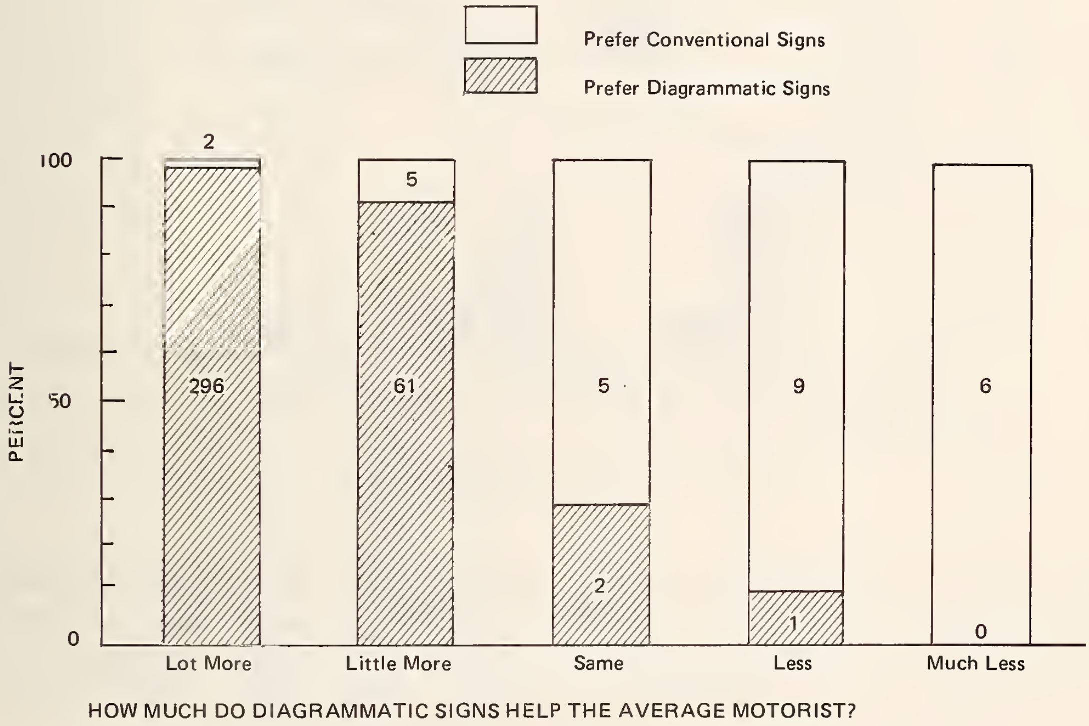

Figure 22. Personal sign preference and assumed assistance to the average motorist.

It is also interesting to note that of the seven motorists who felt that there was no difference between the conventional and diagrammatic signs as an aid to the average motorist, two, or nearly 30 percent, indicated they would still prefer the latter.

Exposure to Diagrammatic Signs

Respondents were asked to indicate how often, if at all, and where they had previously seen graphic signing. The results are shown in Figure 23. This graph by itself, however, does not give an indication of who the 32 percent are that claimed to have never been exposed to diagrammatic signs. A breakdown is given in Figures 23A through 23D relating exposure to license plate, residence and route familiarity (frequency and recency).

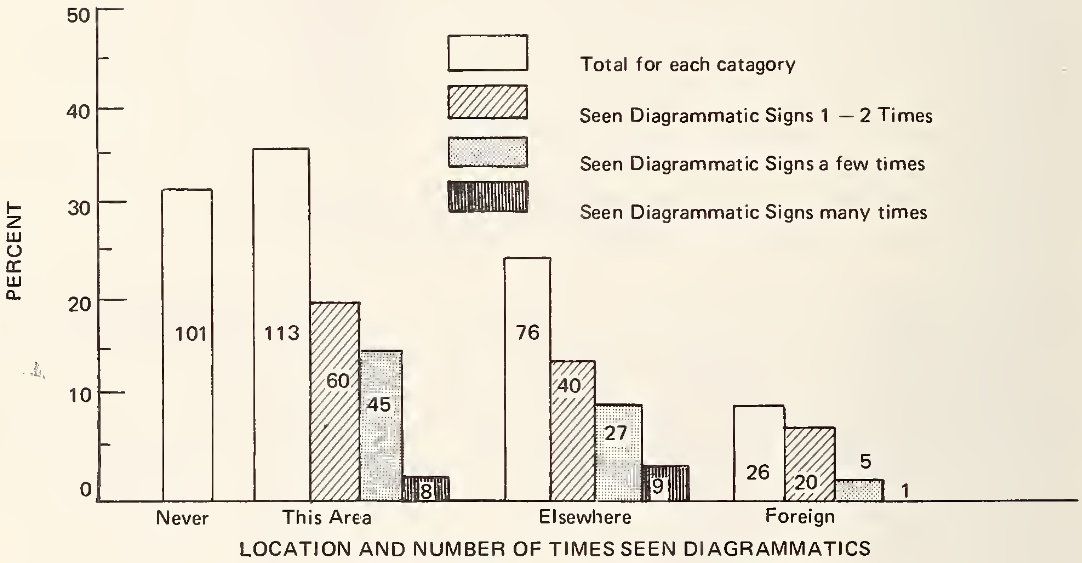

Figure 23. Exposure to diagrammatic signs.

Figure 23A shows that 85 percent of those with local license plates (Maryland, Virginia, District of Columbia or U.S. Government) had seen the new signs in this area, while 37 percent of those with nonlocal plates saw diagrammatic signs only elsewhere. For 60 percent of the foreign license plates, this was their first exposure to graphic signing. A Chi-square test of this relationship is highly significant ($X^2 = 49.62$, df = 6, $p < .001$).

Comparison of the "Never" bars in Figures 23A and 23B shows that more local *residents* than those with local *plates* claimed never to have seen diagrammatics before. The excess is 17 percent. This discrepancy is probably due to the fact that there are individuals living in this area who still have the license plate of their previous residence on their vehicle. Further evidence of this is given below in Figure 45. This relationship is also highly significant ($X^2 = 35.54$, df = 3, $p < .001$).

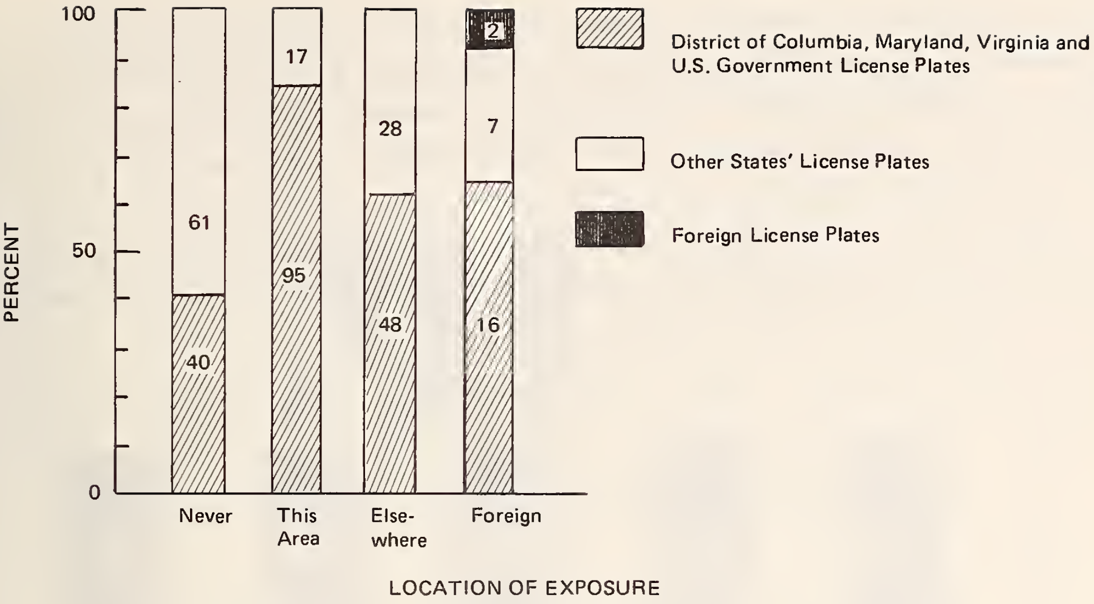

Figure 23A. License plate and exposure to diagrammatic signs.

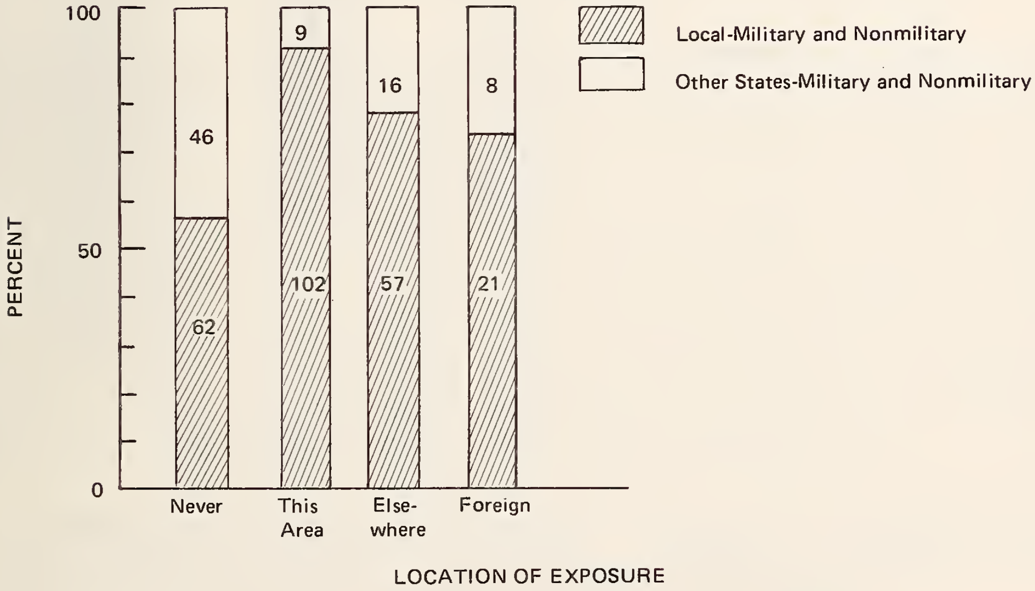

Figure 23B. Residence and exposure to diagrammatic signs.

Route familiarity was measured in two ways: frequency (the number of times the respondent had driven the route before) and recency (whether or not he had driven the route within the past 30 days). Exposure and route familiarity in terms of frequency may be seen in Figure 23C. As the number of times drivers traveled the section of the Capital Beltway increased, the percentage of those reporting they had never seen graphic signing before decreased. However, there are still 18 percent claiming to have seen them for the first time on this particular trip and who had driven the route more than 20 times. A Chi-square test of these data is highly significant ($X^2 = 65.19$, df = 8, $p < .001$).

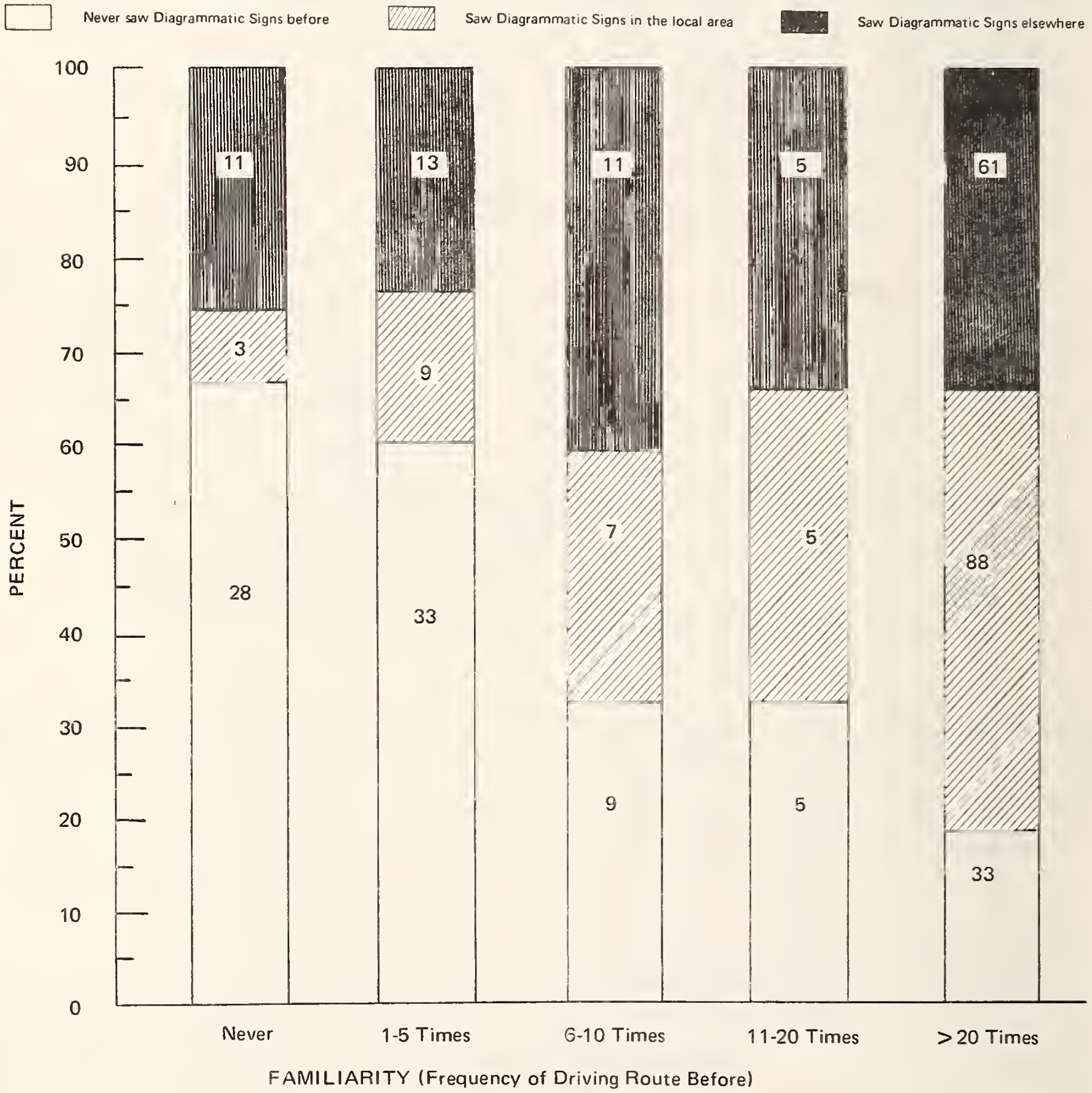

Figure 23C. Familiarity with route (frequency) and exposure to diagrammatic signs.

Familiarity with the route in terms of recency of having driven it and exposure are compared in Figure 23D. Twenty-five percent of those who had driven the route within the previous 30 days claimed to have never seen the graphic signs ($X^2 = 32.27$, df = 4, $p < .001$).

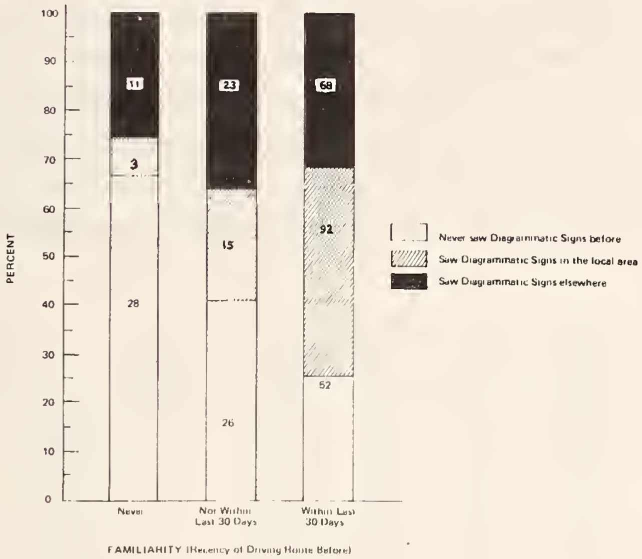

Figure 23D. Familiarity with route (recency) and exposure to diagrammatic signs.

It should be apparent that the exposure data (particularly those who claim to have never seen diagrammatic signs) must be considered with caution. Indeed, in making a total analysis of all respondents, it was found that 23 drivers, or six percent of all questioned had local license plates, had lived in the local area for at least six months, had driven the route a total of 20 or more times and had driven it within the previous 30 days. Yet these said they had never before seen graphic signs. It is quite likely that, as has been suggested in other studies, local, familiar drivers simply do not pay attention to the signs. They know where they are going and do not need guide sign assistance to get to their destination. Since nearly 25 percent of all those indicating that they never saw diagrammatic signs fall into this local-familiar category, it is possible that this phenomenon is present in this study also.

An alternate explanation is that some of these drivers misread the question, interpreting it as: "Have you ever seen diagrammatic signs before other than on this section of the Beltway?" However, it seems unlikely that this accounts for all 23 cases.

Exposure to diagrammatic signing was cross tabulated with driver sign type preference, suspected aid to the average motorist of the signs and difficulty with the signs.

Sign Preference

The bar graph in Figure 24 shows that 93 percent of those respondents who had been previously exposed and 93 percent of those who had no prior experience with them favored the diagrammatic signs. However, the percentage of persons preferring diagrammatic signs does progressively increase as the number of times they are exposed rises. If real, the initial drop to 89 percent preferring diagrammatics with only one or two exposures may be due to the novelty effect which is discussed further below under exposure and sign difficulty.

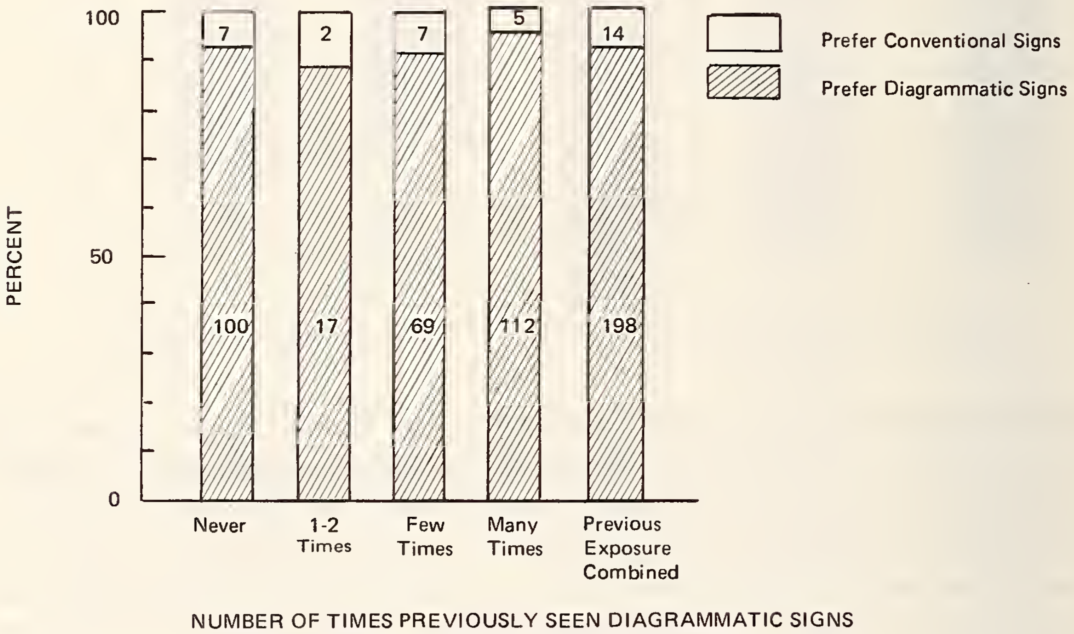

Figure 24. Personal preference for sign type and exposure to diagrammatic signs.

Assumed Assistance to the Average Motorist

Figure 25 graphically illustrates the comparison between driver exposure to diagrammatic signs and driver assumptions concerning the amount of assistance these signs would provide other motorists. The relationship does not reach the .05 level of significance ($X^2 = 3.12$, df = 2, $.20 < p < .30$). Four percent of both those who had and those who had not previously seen diagrammatic signs felt that they were of less help to the average driver than the conventional signing. However, it is interesting to note that the percentage of drivers who felt that there was no difference between the two sign types fell from four percent to one percent as their own experiences with the diagrammatics increased. In other words, as an individual became more acquainted with diagrammatic signing and his sentiments presumedly therefore tended to favor them, his tendency to assume that they would be of more assistance to other motorists also increased. As can be seen graphically in Figures 26A and 26B (a cross tabulation of personal preference and assumed help of the diagrammatic signs for the average driver), 92 percent of those who thought the diagrammatic signs were of more help to other drivers also favored them themselves. Figure 26B shows that 99 percent of the motorists who preferred diagrammatic signs thought that they were more helpful to the average motorist. This relationship is highly significant ($X^2 = 243.91$, df = 1, $p < .001$).

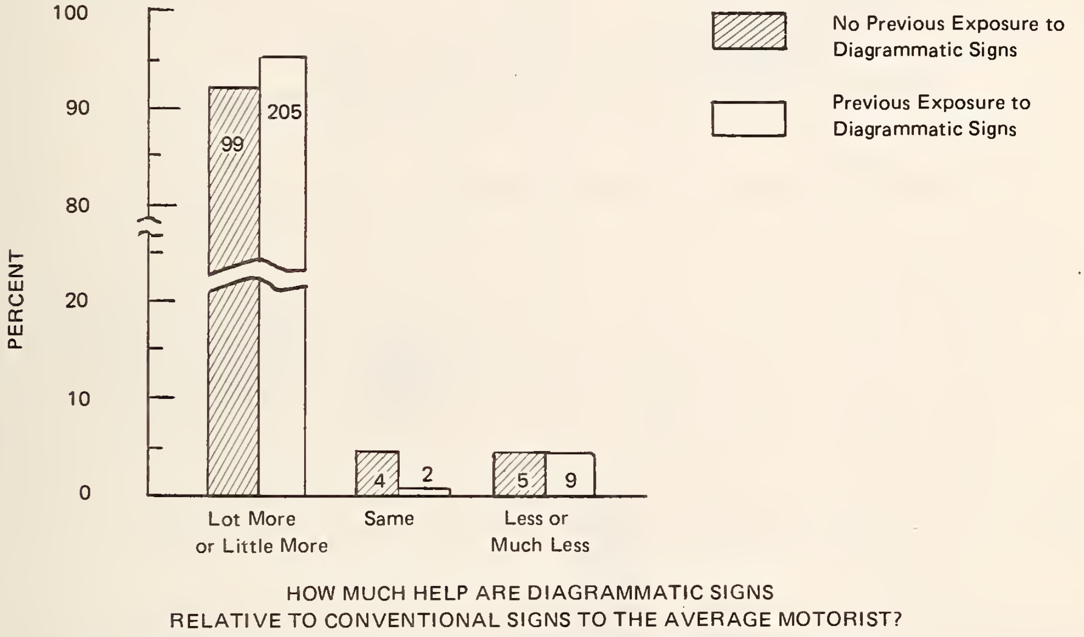

Figure 25. Exposure to diagrammatic signs and assumed assistance to the average motorist.

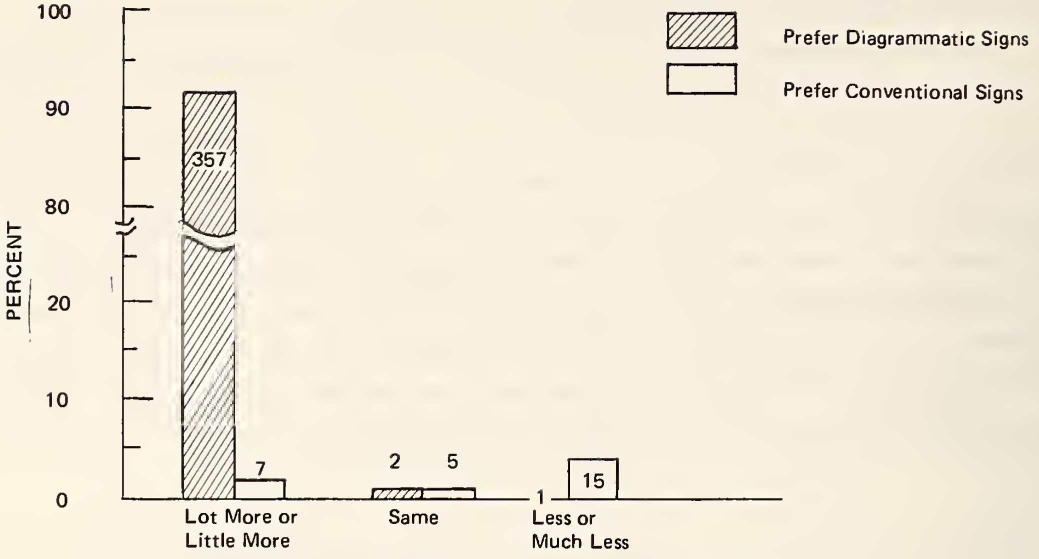

Figure 26A. Sign preference and assumed assistance to the average motorist.

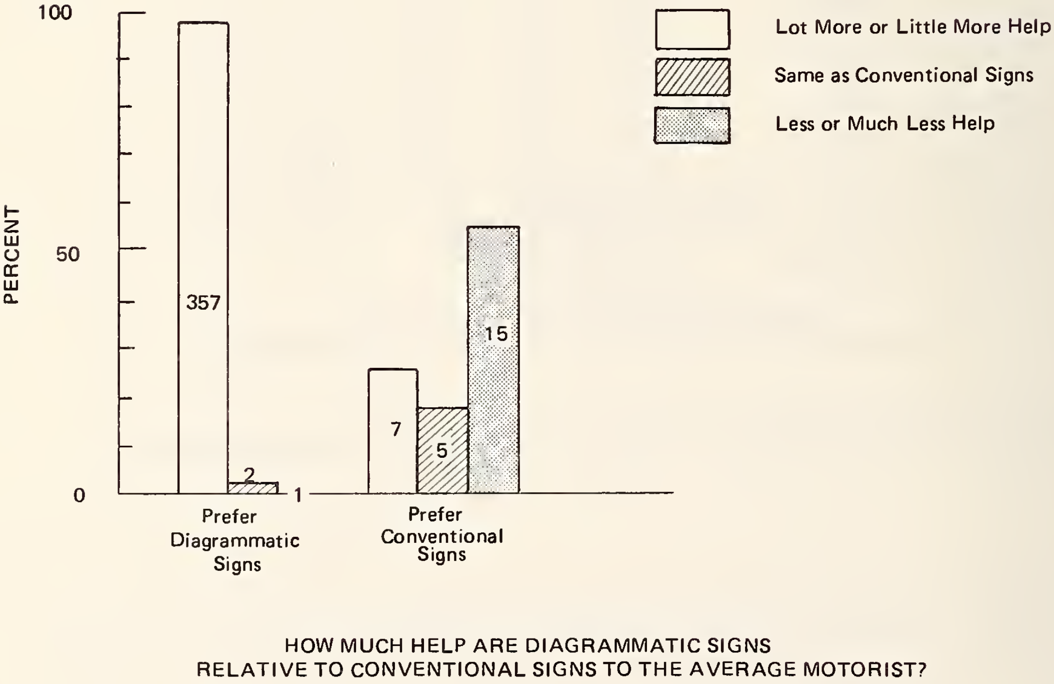

Figure 26B. Sign preference and assumed assistance to the average motorist.

Difficulty With Signs

The percentage of drivers previously exposed but still having difficulty with diagrammatic signs (seven percent, last column) was one-half that of the drivers who had no prior experience (14 percent) as may be seen in Figure 27. A Chi-square analysis of this relationship is significant at the .05 level ($X^2 = 4.60$, df = 1). One possible explanation of this is that diagrammatic signing becomes increasingly helpful as drivers' experience with them increases. The value of experience or education in learning how to properly react to graphic signing is suggested by the fact that 14 percent of those not previously exposed to diagrammatic signs had difficulty while only six percent of those very experienced with them reported trouble. However, the data shown are confounded by route familiarity which increases for some drivers (those who repeatedly drove the test section) along with increasing exposure to the signs.

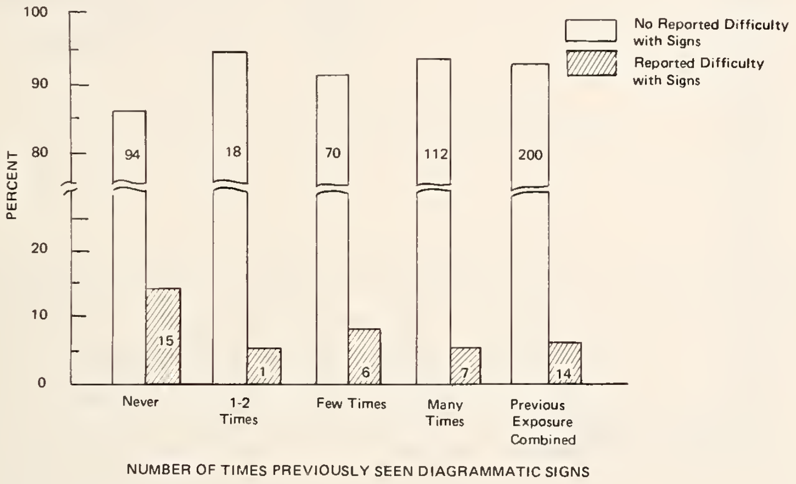

Figure 27. Exposure to diagrammatic signs and difficulty with signs.

To clarify the relationship between experience with the diagrammatics, trouble with them and route familiarity, the subpopulation of drivers who had never driven the route before was isolated. The relationship between reported difficulty with the diagrammatics and previous exposure to them is shown. (Previous exposure was, of course, at locations other than the test situation.) The relationship is highly significant ($X^2 = 12.20$, df = 1, $p < .001$). This strongly suggests that previous experience with diagrammatic facilities use of such signs for route guidance.

	Exposure to diagrammatics	
Difficulty	Never	Elsewhere
Yes	20	8
No	2	12

Sign preference was also cross tabulated with reports of difficulty with the signs and with two demographic items, – sex and age.

Difficulty With Signs

As may be seen in Figure 28, 89 percent of the *total* respondents reported no difficulty and preferred the diagrammatic signs. Note, however, that six percent of those indicating no trouble still favored conventional signing, while 79 percent of those who did report some difficulty still preferred the newer graphic signs. Only two percent of the *total* respondents had difficulty and favored the old signs. A Chi-square test of this relationship is significant at the .01 level ($X^2 = 9.11$, df = 1).

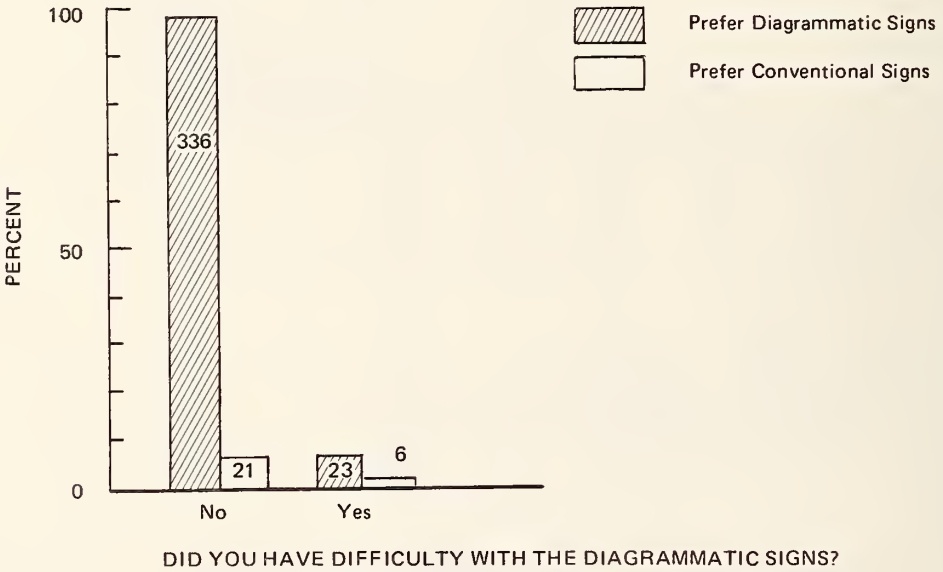

Figure 28. Difficulty with diagrammatic signs and personal sign preference.

Sex

Figure 29 gives the data for sex versus personal sign preference. There is no significant difference between males and females. This cross tabulation was of interest because of anecdotal evidence collected very early in the study suggesting that women found diagrammatic signs more novel and more confusing than men did. No evidence to support this was found, however. Ninety-four percent of the males and 91 percent of the females, combining to 93 percent of the total responding, preferred diagrammatic signing. A Chi-square test of these data is not significant ($X^2 = 1.09$, df = 1, $.30 < p < .50$).

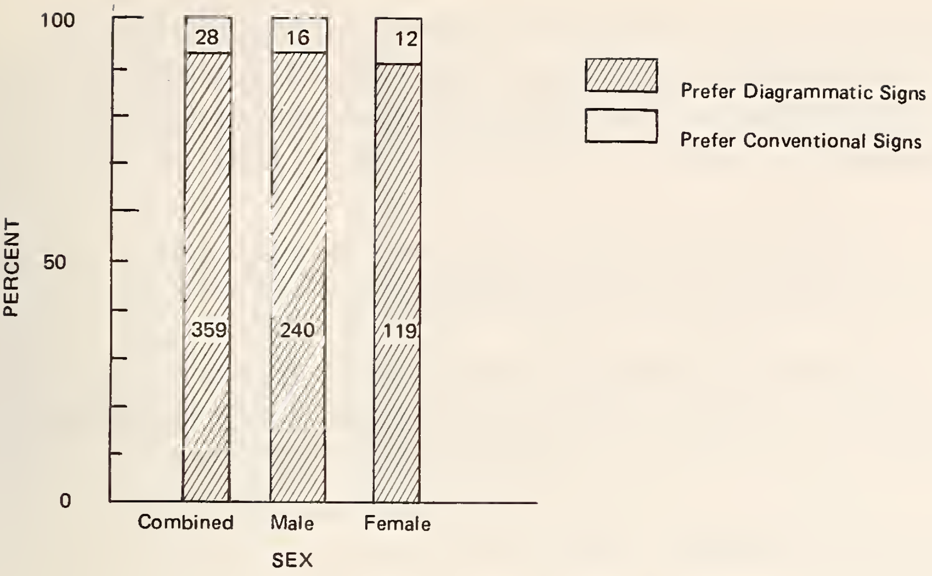

Figure 29. Sex and personal sign preference.

Age

It may be expected that older drivers would tend to favor conventional signing more than would younger drivers since the older drivers would be relatively more adapted to them and thus more resistant to change. As is shown in Figure 30, this is not the case. Excluding the less than 21 years old category which is very small (only six cases and thus to be considered with caution), the variation between the percentages of respondents favoring diagrammatic signs is six percent: from 90 percent of those 31 to 40 years of age to 96 percent of those 21 to 30 years of age. A Chi-square test is not significant ($X^2 = 4.31$, df = 4, $.50 < .30 < p$).

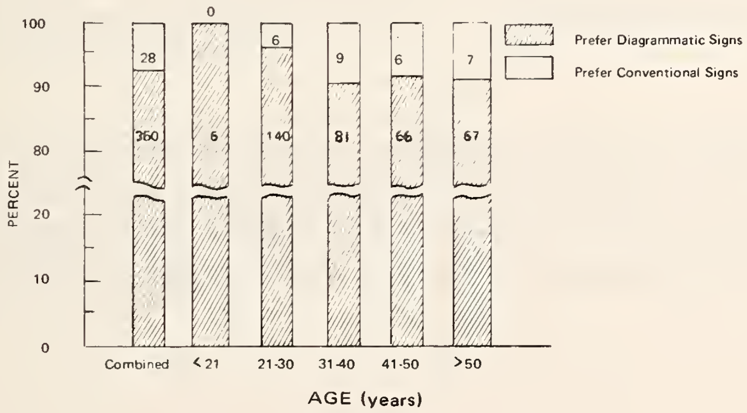

Figure 30. Age and personal sign preference.

Many of the motorists interviewed had interesting comments which could not be adequately summarized by cross tabulation. Since many of these comments relate directly to the diagrammatic signs and/or driver reaction, interpretation, or attitudes toward them, they deserve attention in this section.

While the majority of unique comments were favorable remarks on sign clarity and ease of interpretation, other more specific items were also identified.

As shown in the cross tabulations, the majority of interviewees responded favorably to the diagrammatic signs. In addition to generally good responses, many stated specific aspects of the signs which they liked or, in some cases, considered confusing.

A few of the more frequent favorable comments were:

- "Extremely helpful–gives an idea of what is coming–*exactly*."
- "First experience is qualified success."(This driver's first experience with these signs.)
- "Very helpful in determining which lane to stay in. Also, easy to read at a quick glance."
- "Very informative as to which direction to follow."

Although the majority of the drivers interviewed stated a preference for the diagrammatics, many of these same people indicated a definite learning time was required for adjustment or change in road sign reading habits. Following this same pattern are people expressing negative attitudes toward the new signs but also suggesting uniformity in signing, *regardless* of sign type, as a possible solution for confusion experienced by unfamiliar drivers. One person summarized the problem like this: "Good, but confusing since this is the only place with them." Similarly, another person said: "They help. The first one is confusing but after grasping them, they are very good."

Another proposed solution was an intermediate step toward the elimination of confusion during transition from conventional signing to diagrammatics; seven people, all nonlocal or recent locals, suggested a combination of conventionals and diagrammatics within each interchange. One person said: "We need both for the people who do not understand the new signs the first time."

Across interviews (exit, thruput and selected) there was an overwhelming number who mentioned their clarity and visibility as a major point in their behalf. Some of these respondents even went so far as to specify their nighttime visibility as being superior to that of conventionals because the graphic enabled them to visualize the roadway geometry and react accordingly.

There were specific areas which appeared to be causing confusion and, therefore, negative responses among motorists. While these comments are negative in nature, they are specific to particular signs. From other information in the questionnaires filled out by these same motorists, these comments should not be interpreted as opposed to all forms of diagrammatic signing. Listed below are some examples.

- "Generally good, but 16 South confusing because of information placement (route number relationship to specific line is unclear)." ("Specific line" refers to the two exit ramps shown on this sign.)
- "Full arrow going all the way around is not necessary–confusing–just have a short arrow." (Democracy Boulevard)
- "The ones on the Beltway (designating the Beltway and exit) are not confusing and probably helpful. The ones off the Beltway (at exits designating east and west) are something extra to observe and may be confusing." (16 North on the ramp).
- "Not well made–too much detail–16 North off ramp (tangential) good."

In addition to comments related to diagrammatics, a surprisingly high number of people had negative comments about other areas of I-495/I-70S and other main routes surrounding Washington such as I-95. The comments which applied to *all* of these routes centered around the lack of advance warning for approaching interchanges. About 40 percent of the respondents who noted particular problems with the I-95 North approach to the Capital Beltway suggested stack signing as a solution.

A review of general comments from the thruput interviews shows 50 percent of all remarks related to the I-95N/I-495 interchange. These comments identified poor signing, roadway geometry or both as problem sources. About 85 percent of these people indicated a preference for diagrammatics. Several suggested a graphic sign and/or a change in destination names might be of help.

Difficulty with Guide Signs (Before/After Data)

In this section, the data from the Before and After studies are compared in an attempt to find relative differences in reported driver difficulty with conventional and diagrammatic signing. Relationships between reports of trouble and route familiarity, trip length, map usage, license plate and two demographic characteristics—age and sex—were investigated.

Sex

Of the male respondents, 16 percent reported that they had trouble with the conventional signs, whereas seven percent reported difficulty with diagrammatic signing. Of the female respondents, ten percent indicated conventional sign difficulty and nine percent reported trouble with the graphic signs (see Figure 31). A Chi-square test of sex versus reported difficulty with the signs is not significant in either the Before or After study (conventional: $X^2 = 2.46$, $df = 1$, $.20 > p > .10$; diagrammatic: $X^2 = .67$, $df = 1$, $.50 > p > .20$).

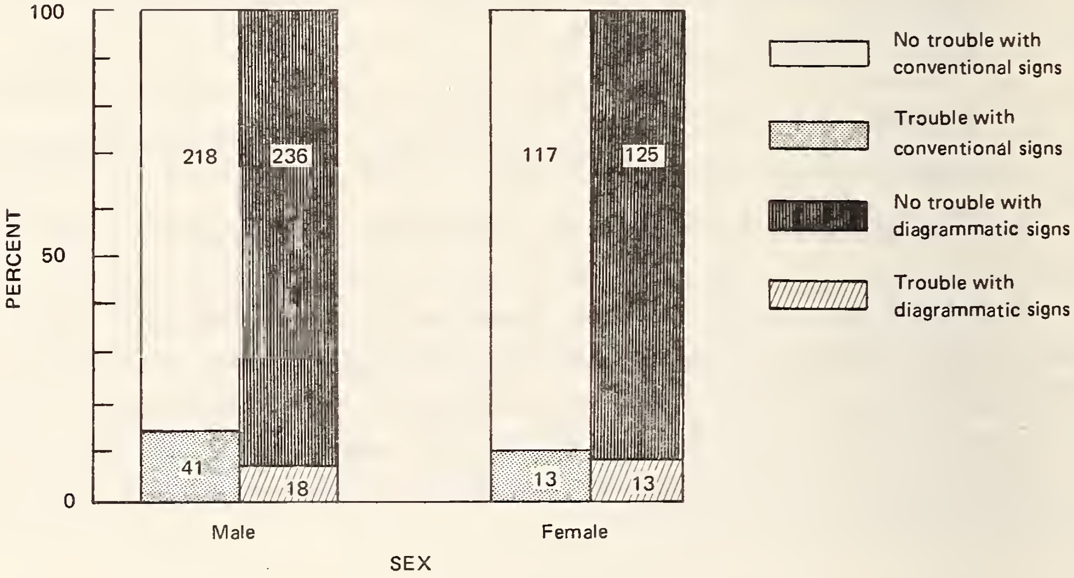

Figure 31. Sex and trouble with signs.

A Kolmogorov-Smirnov test was run on the Before and After data for each sex with a significant difference found in the male data ($D = .215$, $p = .01$, two-tailed test).

Age

A graphic comparison in reports of trouble or of no trouble with the guide signs is shown in Figure 32. Generally the older drivers, particularly those over 50 years old, more frequently reported difficulty with the signs (both conventional and diagrammatic) than did the intermediate groups. This should be expected since older drivers more frequently have reduced capabilities (Eberhard, 1970) which tend to increase this group's difficulty with the driving task, including understanding and reacting to road signs. The younger group (less than 20 years of age) also shows this tendency but since the sample of drivers in this category is small (five cases for conventional and six for diagrammatic signs), the data must be viewed with considerable caution. A Chi-square test of these data did not reach the .05 significance level for either the Before or After phase (conventional: $X^2 = 9.04$, df = 4, $.10 > p > .05$; diagrammatic: $X^2 = 7.44$, df = 4, $.20 > p > .10$).

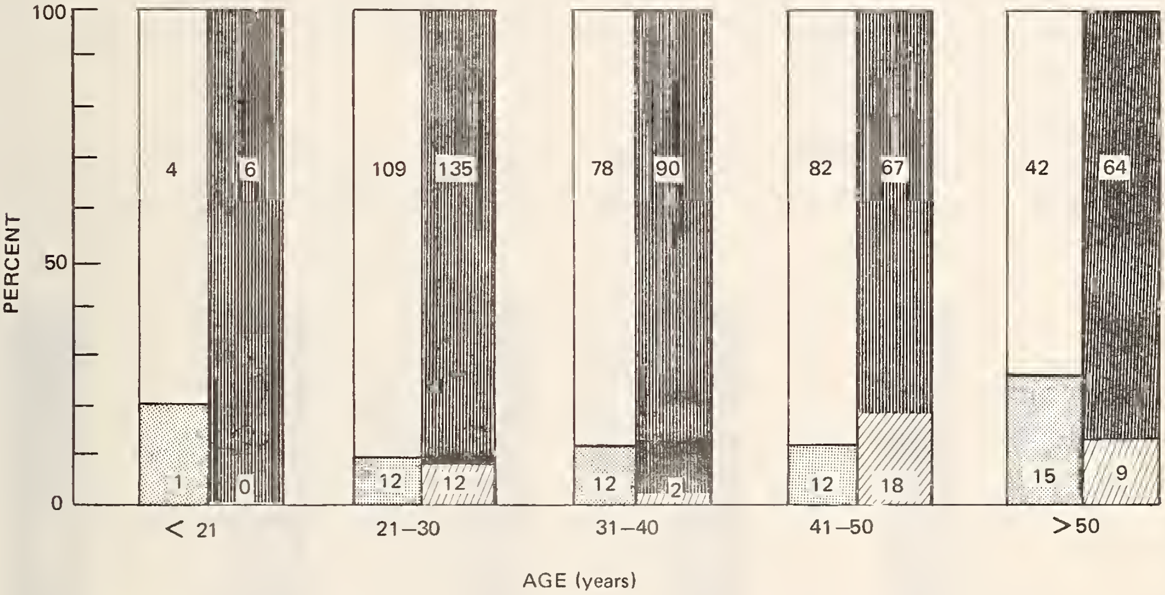

Figure 32. Age and trouble with signs.

Using the Kolmogorov-Smirnov test, a significant difference was found between the Before and After data for the 31 to 40 year old age group. All others were not significant ($D_{31\text{-}40} = .393$, p = .05, two-tailed test).

Relationships between trip characteristics and trouble or lack of trouble with the guide signs are of considerable interest. Route familiarity, map usage and trip length as related to difficulty with the conventional and diagrammatic signs were assessed.

Familiarity with Route

It would be expected that those having the greatest familiarity with the route would report the least trouble with the route guidance signs and vice versa. Both the Before and After data bear this out.

Considering frequency first, Figure 33 shows that as familiarity with the route increases from no driving experience on the route to previous driving experience on the route of 21 times or more, reports of trouble with the signs decreased under the conventional and diagrammatic conditions. Chi-square tests were highly significant (conventional: $X^2 = 44.25$, df = 4, $p < .001$; diagrammatic: $X^2 = 45.60$, df = 4, $p < .001$).

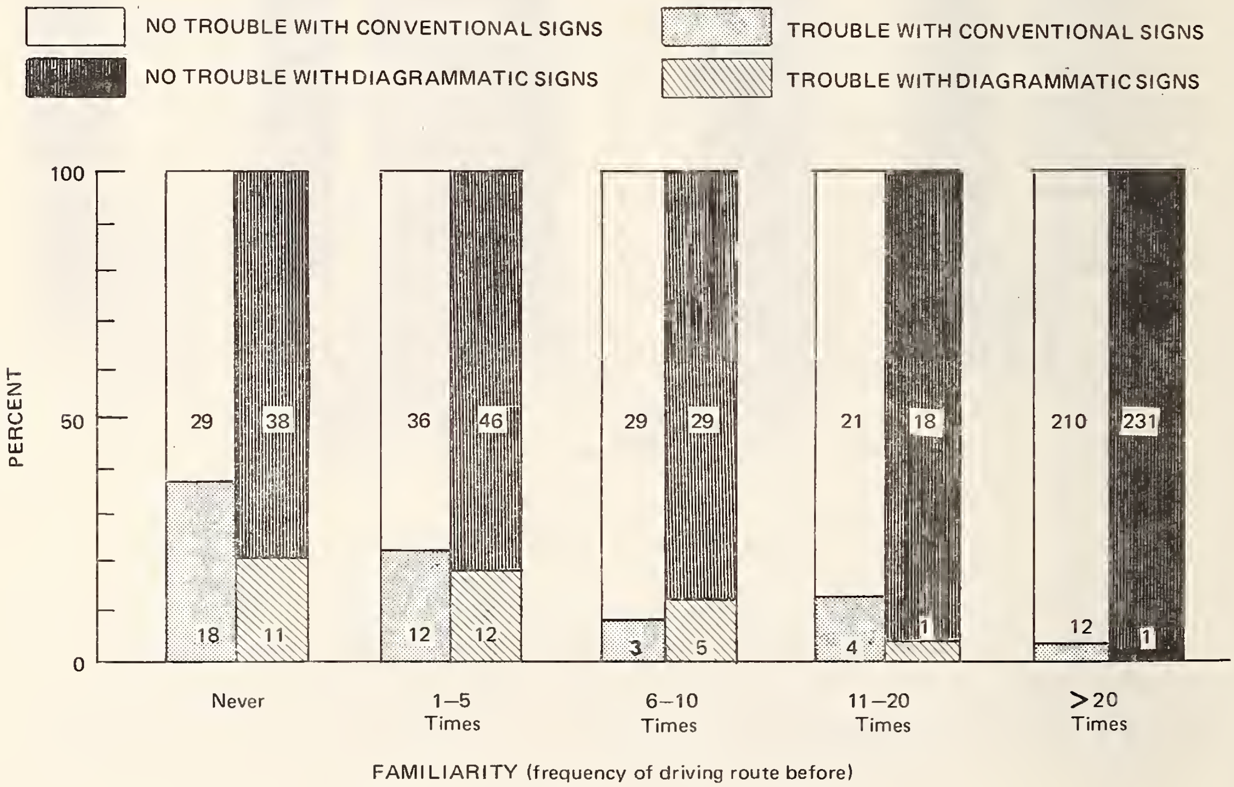

Figure 33. Past frequency of driving route and trouble with signs.

A Kolmogorov-Smirnov test shows a significant difference of .05 for those who traveled the route more than 20 times between the change from conventional to diagrammatic signs ($D = .381, p = .05$, two-tailed test). As an interpretation of this finding, it is possible that the diagrammatic signs may indeed be better than conventional ones but only after the initial novelty period has worn off. Once drivers have learned how to correctly read and react to graphic signs, which is presumedly the case for those who were on this route more than 20 times, their behavior shows a significant improvement.

In terms of recency, Figure 34 shows that reports of difficulty with the signs increases across the three categories (never to within the past 30 days) from six percent to 38 percent for the conventional signs and from three percent to 23 percent for the diagrammatic signs. The relationship is highly significant for both cases (conventional: $X^2 = 47.33$, df = 2, $p < .001$; diagrammatic: $X^2 = 31.90$, df = 2, $p < .001$).

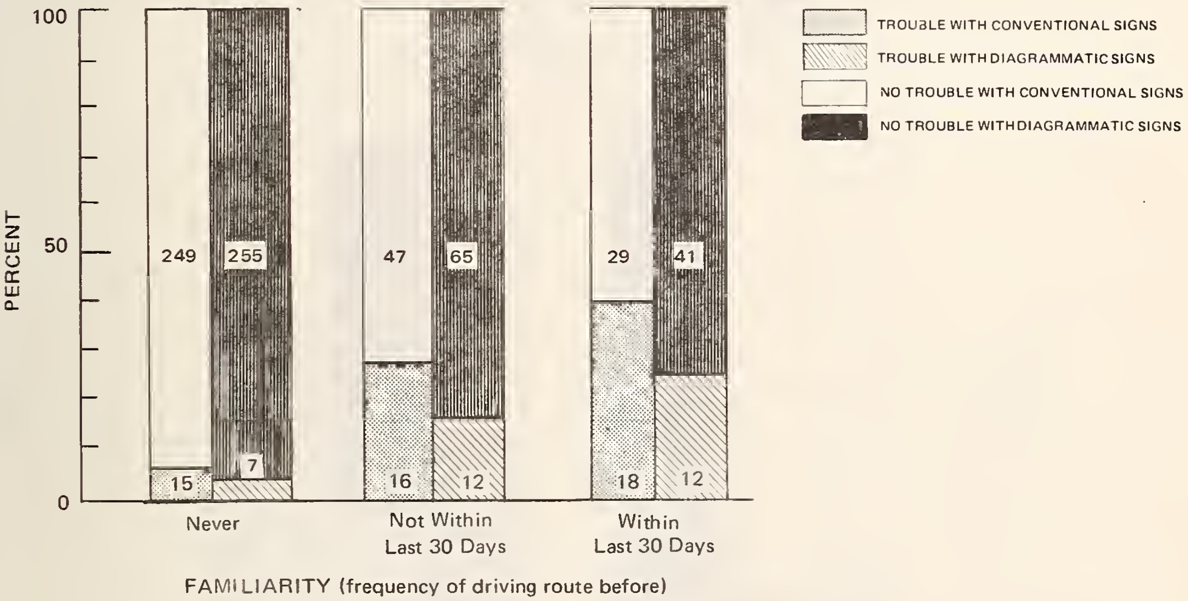

Figure 34. Recency of driving route and trouble with signs.

Although there is a lower percentage of persons reporting trouble with diagrammatic signs in all three categories, a Kolmogorov-Smirnov test does not indicate this to be a significant difference.

In view of the above, it is not surprising that when the most familiar and least familiar (in terms of both recency and frequency) are compared with signing difficulty, the relationship is also highly significant under both the conventional and diagrammatic sign situations. The data are shown in Figure 35. In the Before phase five percent of those who had driven the route 21 times or more and within the last 30 days reported difficulty with the signs. Thirty-eight percent of those who had never driven the route before reported trouble with the signs ($X^2 = 44.00$, df = 1, $p < .001$). With diagrammatic signs, only one percent of those most familiar with the route reported sign difficulty whereas 23 percent of those who had never driven it before indicated trouble ($X^2 = 37.83$, df = 1, $p < .001$).

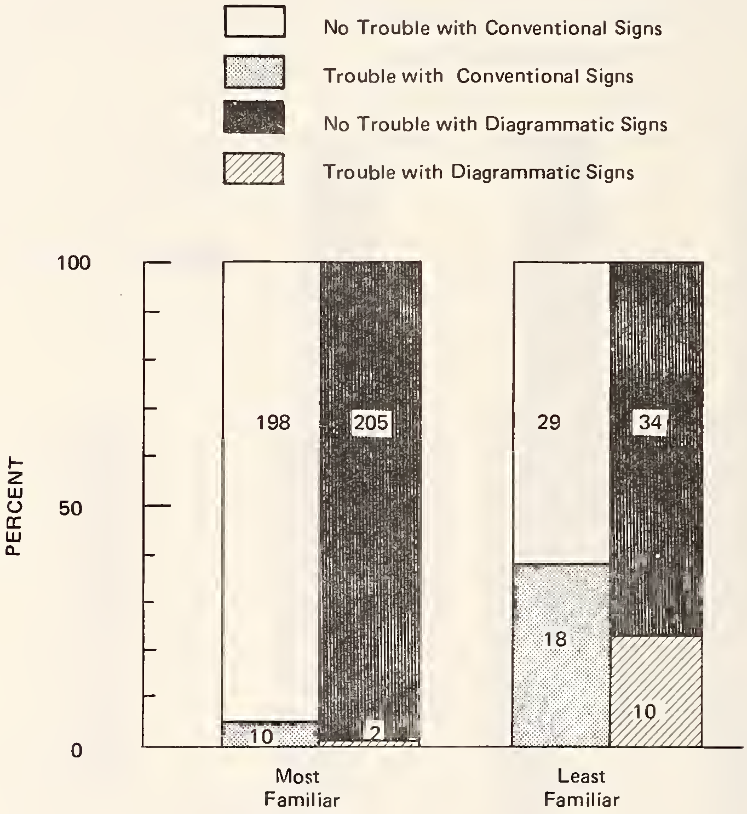

Figure 35. Familiarity with route and trouble with signs.

While there is a decrease in the percentage of persons reporting difficulty in both cases with the diagrammatic signs versus conventional signs, a Chi-square test indicates that this is significant only in the most familiar category ($X^2 = 5.46$, df = 1, $.02 > p > .01$). This may be interpreted as was the data above for familiarity versus sign difficulty: diagrammatic signs, once drivers become acquainted with them, may be more helpful than conventional signs. Recall that this phenomenon was mentioned by several of the drivers as was pointed out above in the discussion on graphic comments.

Map Usage

As familiarity with the route increases, measured by either frequency or recency, map usage declines. In terms of frequency (Figure 36), map usage declines from 69 percent for those who have never driven the route before to four percent for those who have driven it 21 times or more. Data from the Before and After studies were combined here since no distinction is made between the two signing conditions. There are not, however, significant differences between Before and After data. This relationship is highly significant ($X^2 = 266.22$, df = 4, $p < .001$).

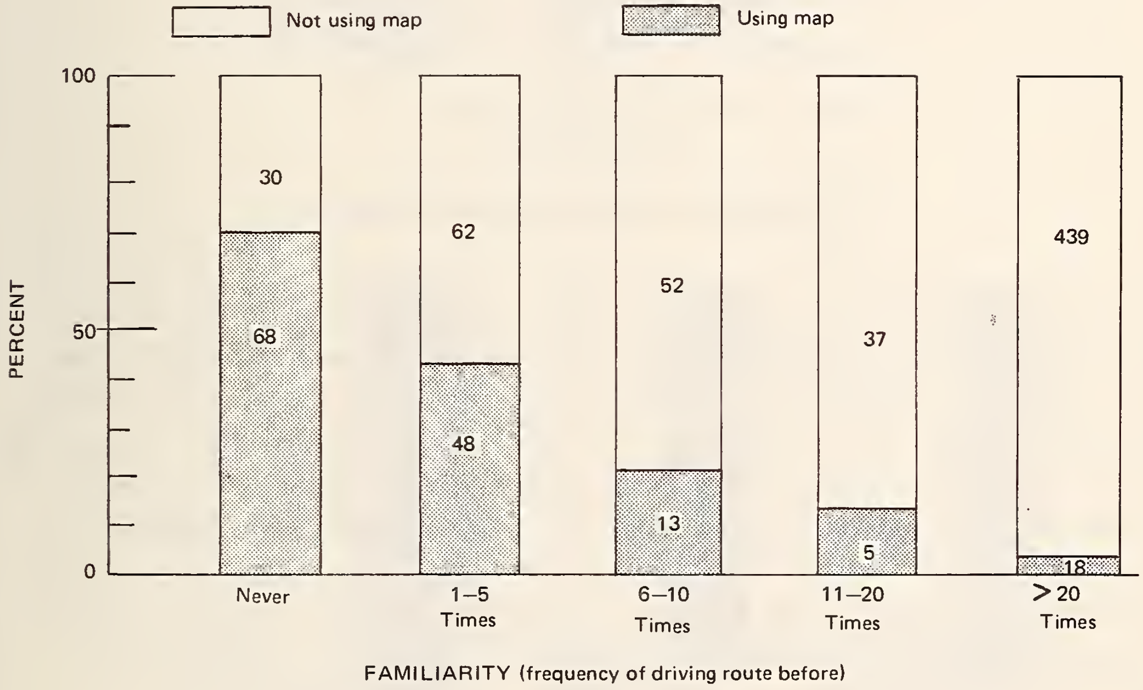

Figure 36. Past frequency of driving route and map usage.

In terms of recency (Figure 37) map usage declines from 65 percent for those who had never driven the route before to eight percent for those who drove it within the previous 30 days. The relationship is highly significant ($X^2 = 190.93$, df = 2, $p < .001$).

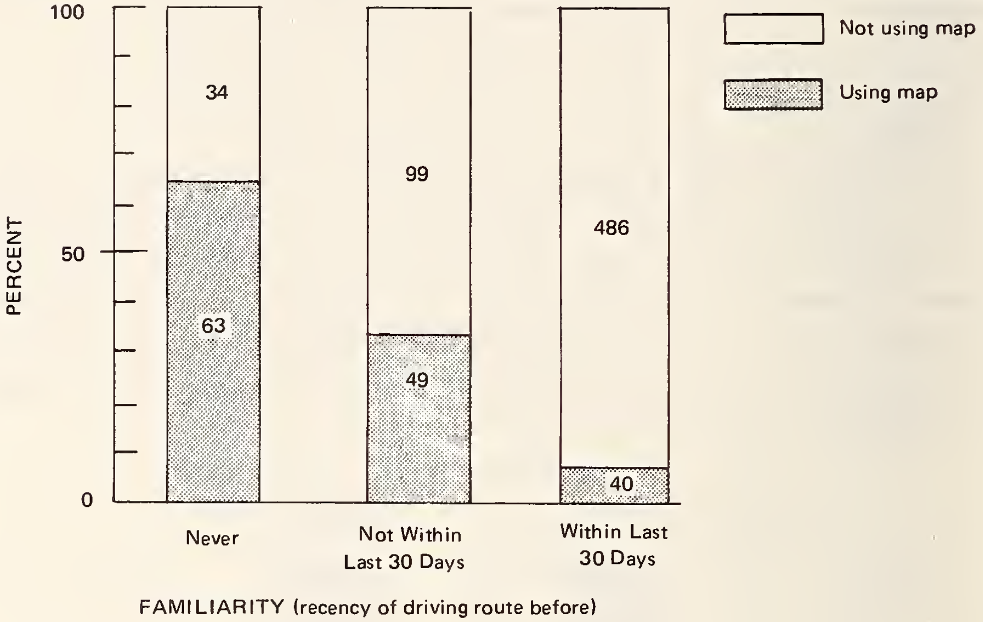

Figure 37. Recency of driving route and map usage.

Although the above two Chi-squares were figured using the combined Before and After data, the significant relationship between map usage and familiarity suggests that a significant relationship should also occur between use of maps and reports of difficulty with the signs since familiarity and trouble were shown to be related. This is indeed the case. Under conventional signing conditions, 33 percent of those using maps reported trouble with the signs whereas only ten percent of those not using maps reported difficulty (Figure 38). With diagrammatic signs, 19 percent using maps indicated trouble and only four percent not using a map reported sign difficulty. In both cases, the relationships are highly significant (conventional: $X^2 = 25.25$, df = 1, $p < .001$; diagrammatic: $X^2 = 20.21$, df = 1, $p < .001$).

Trip Length

Significant relationships were found between route familiarity and trouble with signs and between map usage and trouble with signs. Thus, a significant relationship might be expected to exist between trip length and trouble with signs. Such a relationship was found (Figure 39).

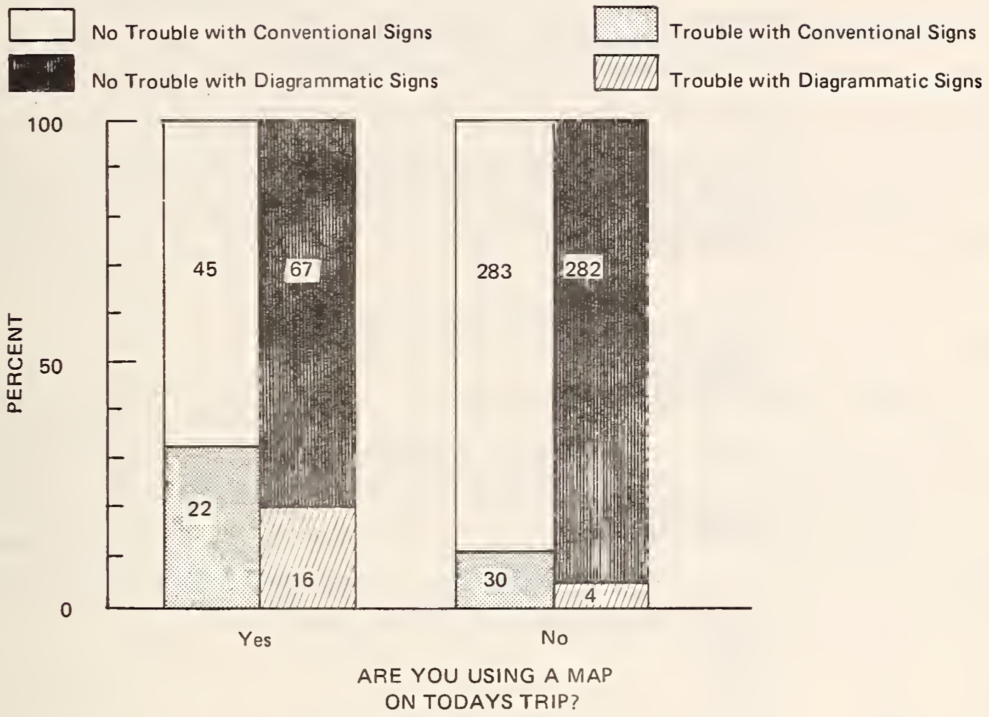

Figure 38. Trouble with signs and map usage.

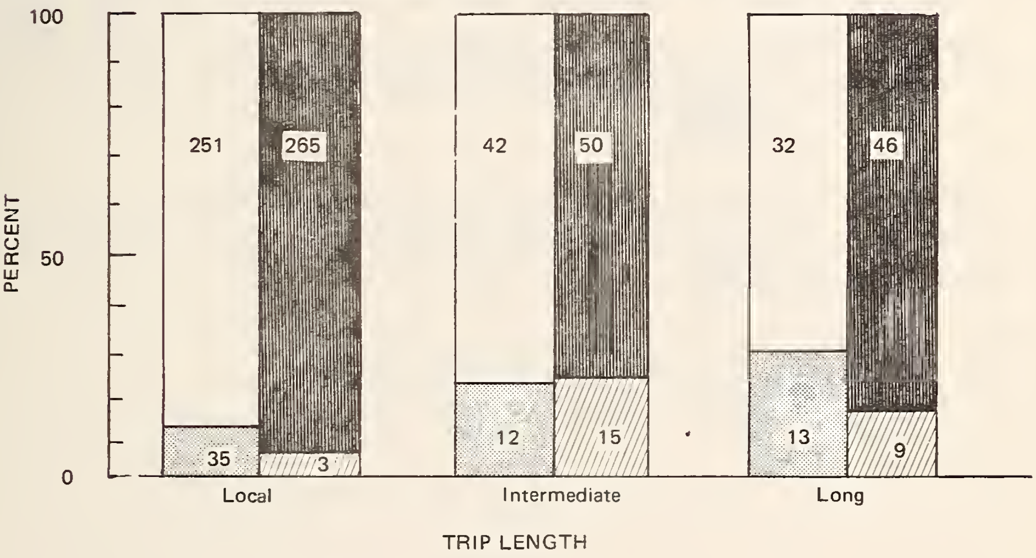

Figure 39. Trouble with signs and trip length.

Trip lengths were divided into three groups based on the stated origins and destinations of the respondents. Local trips are those originating and terminating within 30 miles of Washington, D.C. Long trips are those originating and terminating greater than 100 miles from Washington, D.C. All others are classified as intermediate trips. As trip length increases across the three categories, reported difficulty with conventional guide signs increased from 12 percent to 22 percent to 29 percent. This relationship is significant at the .01 level ($X^2 = 10.29$, df = 2). For the diagrammatic signs, the reports of difficulty increased from three percent to 23 percent and then dropped to 16 percent for the long distance travelers. This relationship is highly significant ($X^2 = 36.56$, df = 2, $p < .001$).

License Plates

Figure 40 indicates that a few drivers had difficulty with both types of signs. However, with the exception of the "Other East" category, a smaller proportion of drivers reported difficulty with the diagrammatic signs than with the conventional signs. The numbers within each category are too small for meaningful significance testing. However, the trend is important. When the data are combined across license plates, the relationship between type of sign and reports of difficulty with the sign is significant ($X^2 = 7.18$, df = 1, $p < .01$).

Preferred Information

Cross tabulations and relationships concerning preferred information and license plates (the next section) were made by combining data from the Before and After studies. This was done since the comparisons under consideration are not directly related to the differences between conventional and diagrammatic signing but are of interest to the study.

All respondents in both phases of the study were asked to indicate what information would have been most useful to them on the I-495/I-70S exit signs. Relationships between preferred information and the following were analyzed:

- Trouble with signs
- Trip length
- Sex

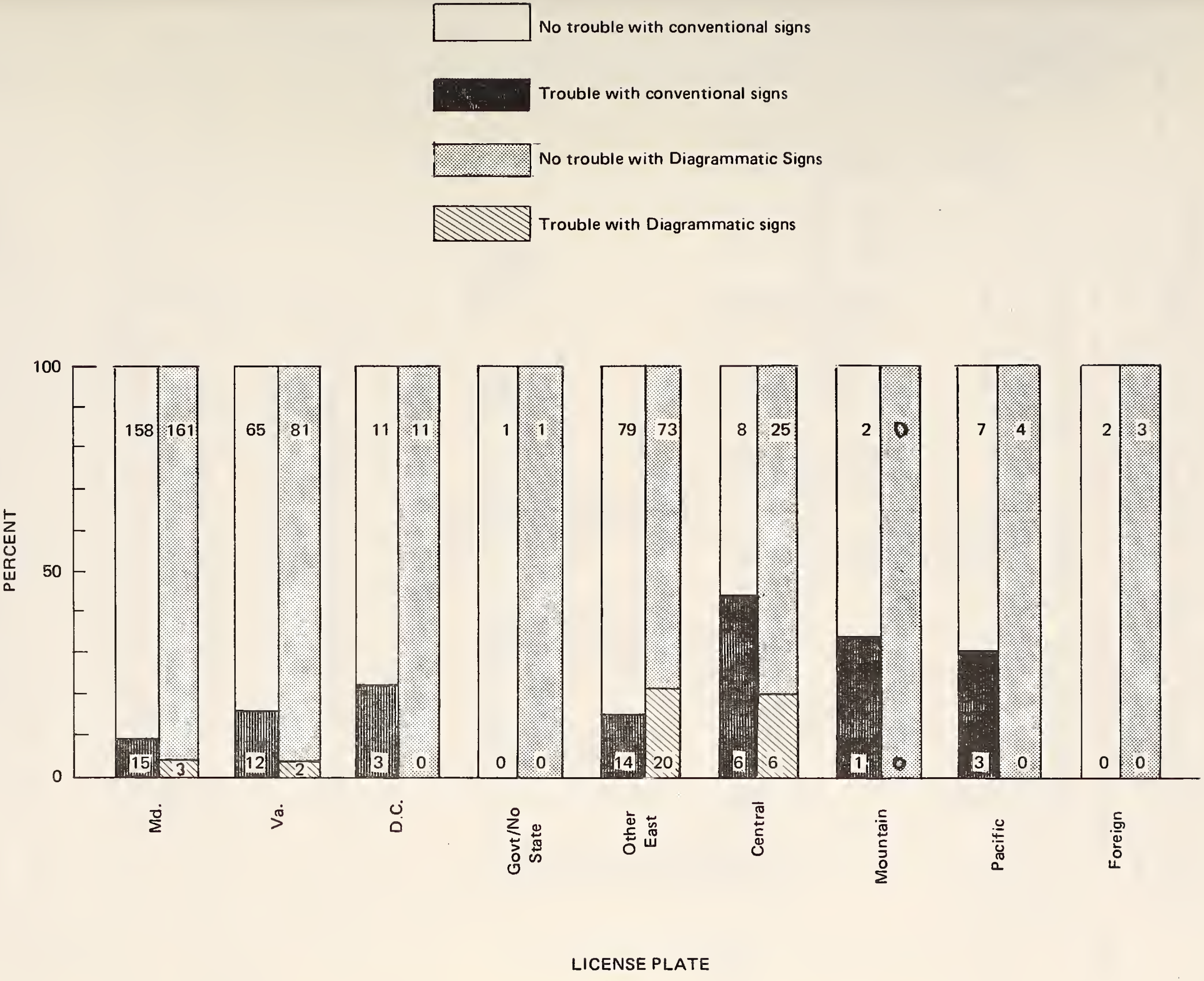

Figure 40. License plate and reports of trouble or no trouble with signs.

Trouble with Signs

The bar graph in Figure 41 shows the combined percentage of responses favoring each of the six categories of signing information for those reporting difficulty with the signs and those reporting no difficulty. City name and route number are cited most often by those having no trouble while city name and cardinal direction are cited most frequently by those reporting sign difficulty. The Category of "Other" information, quite often the name of a shopping center, was cited more often by those having trouble than by those not having problems with the signs. A Chi-square test of these data was highly significant ($X^2 = 32.14$, df = 5, $p < .001$).

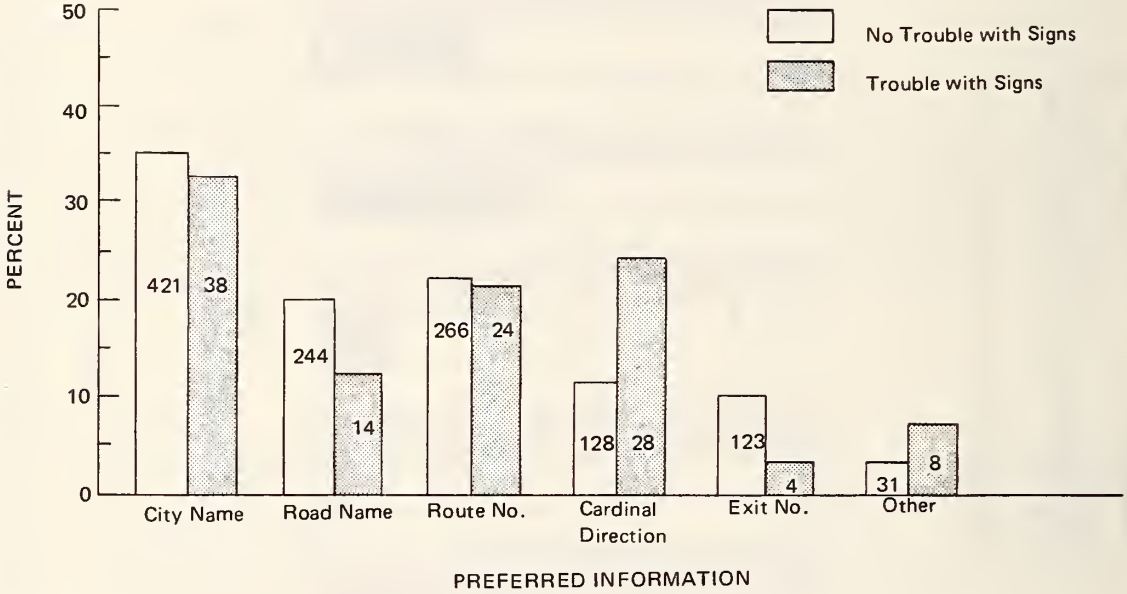

Figure 41. Information preferred and difficulty with signs.

Trip Length

It will be remembered that trip length and trouble with the signs were significantly related. The different preferences for information by those having difficulty with the signs and those not having difficulty suggest that some basis for difference may be in the length of the trip.

The bar graph in Figure 42 shows the percentage of times that each category of information was chosen by those making local, intermediate and long trips. City name and road name are less frequently cited as trip length increases while route number and cardinal direction increase in importance. The "Other" category is most important to those making intermediate length trips. A Chi-square test of trip length and preferred information was highly significant ($X^2 = 60.66$, df = 10, $p < .001$, combined data).

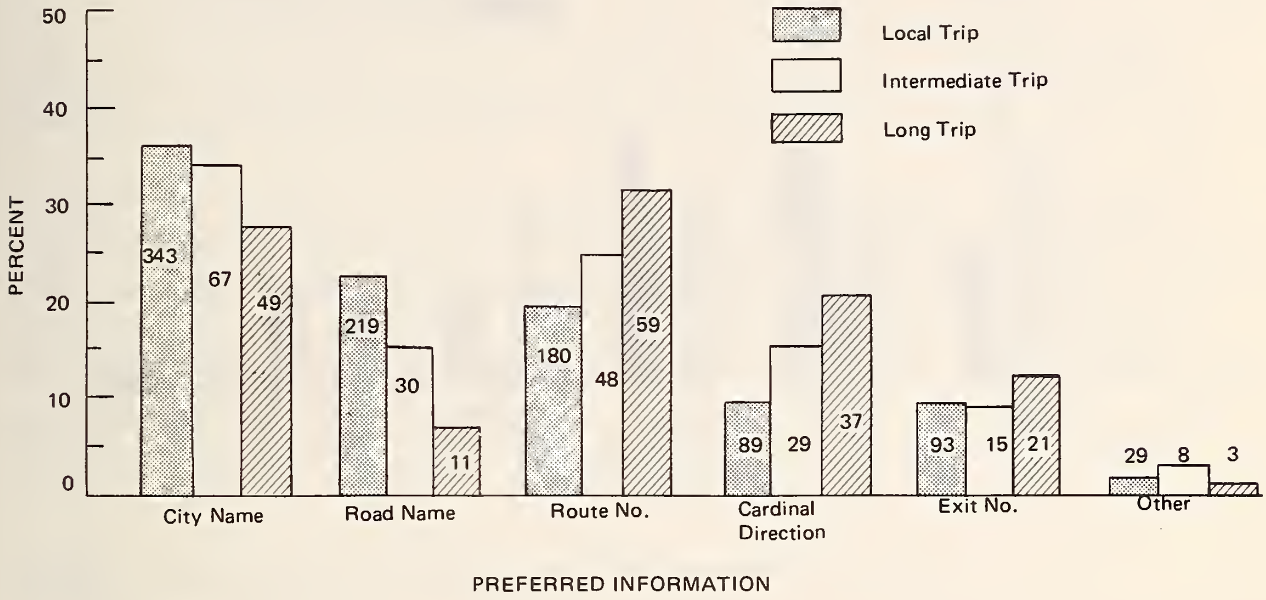

Figure 42. Information preferred and trip length.

Sex

In the After study respondents were asked to indicate their first and second choice for preferred information. Figure 43 shows the percentage of males and females choosing each of the categories of signing information. A Kolmogorov-Smirnov test indicates a significant difference in first choices between sexes but no significant relationship between second choices (first choice: D = .188, p = .01; second choice: D = .096, $p < .10$). The tendency for females to favor a name (destination or road) and males to disproportionately favor route number may be a function of the types or length of trips each sex tends to make, however.

Figure 44 shows the percentage of males and females choosing each of the categories of signing information combining Before and After data and first and second choices. The percentage of females selecting destination and road name was somewhat higher than the percentage of females in the sample, whereas men selected route number and cardinal direction more frequently than they were represented in the sample. A Chi-square test is significant ($X^2 = 14.02$, df = 5, $p < .05$).

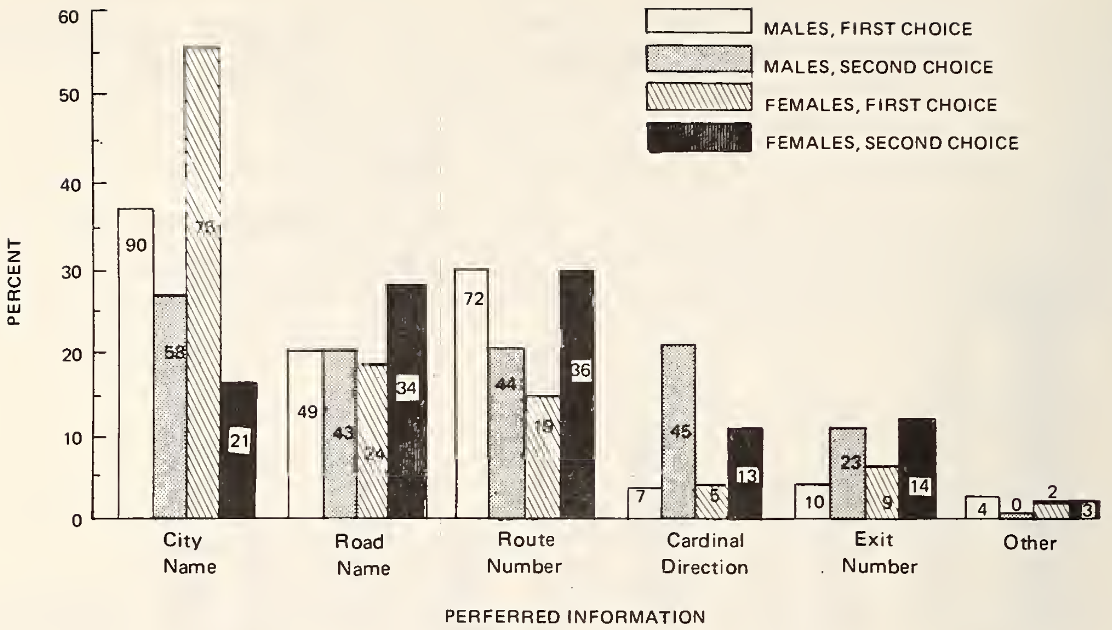

Figure 43. Information preferred by sex and first and second choices (After study data).

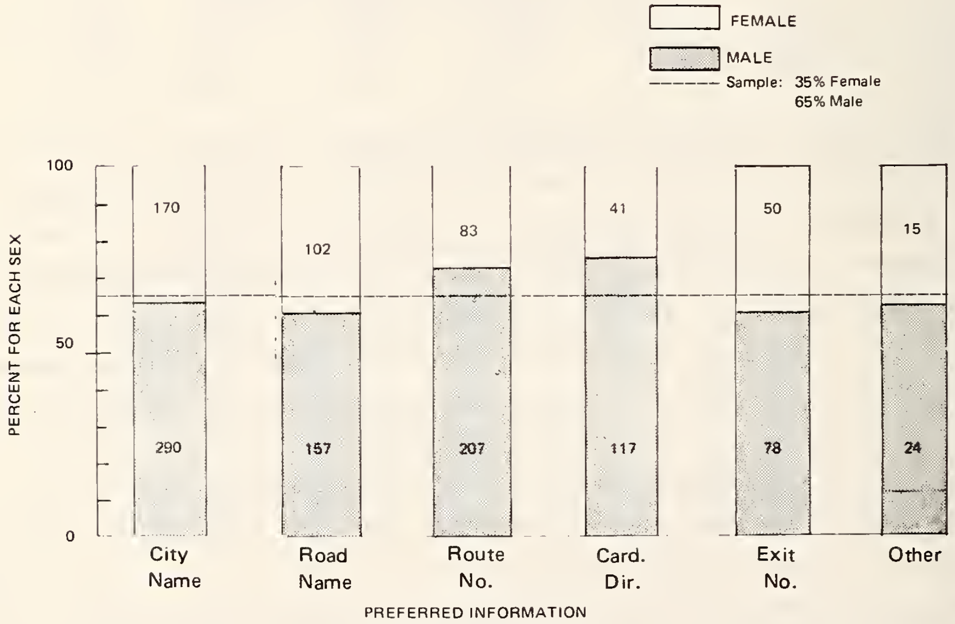

Figure 44. Information preference by sex and combined first and second choices (combined data).

License Plate

Cross tabulations of residence and route familiarity against license plate were made. It will be remembered that the license plate of each vehicle was filled in by the questionnaire administrator on a separate cover sheet. This was done to ensure correct disclosure of place and period of residence by the respondents. Discrepancy between these and the license plate, had this item been filled in by interviewees, might have been threatening and caused them to be less than fully cooperative.

These cross tabulations are of particular interest for the analysis of data collected with the Traffic Evaluator System. In the manual coding of vehicles, Maryland, Virginia, District of Columbia and U.S. Government license plates were coded as local, all others were coded as foreign. The purpose was to separate local, and therefore presumed familiar drivers, from nonlocal and presumed unfamiliar drivers so that the behavior characteristics associated with each of these groups could be compared. These cross tabulations allow estimation of how valid license plates are for identifying the two groups of drivers.

Residence

The bar graph in Figure 45 shows the relationship between residence and license plate. Those residing on military bases are grouped separately due to the higher expectation of nonlocal persons stationed there relative to the civilian population.

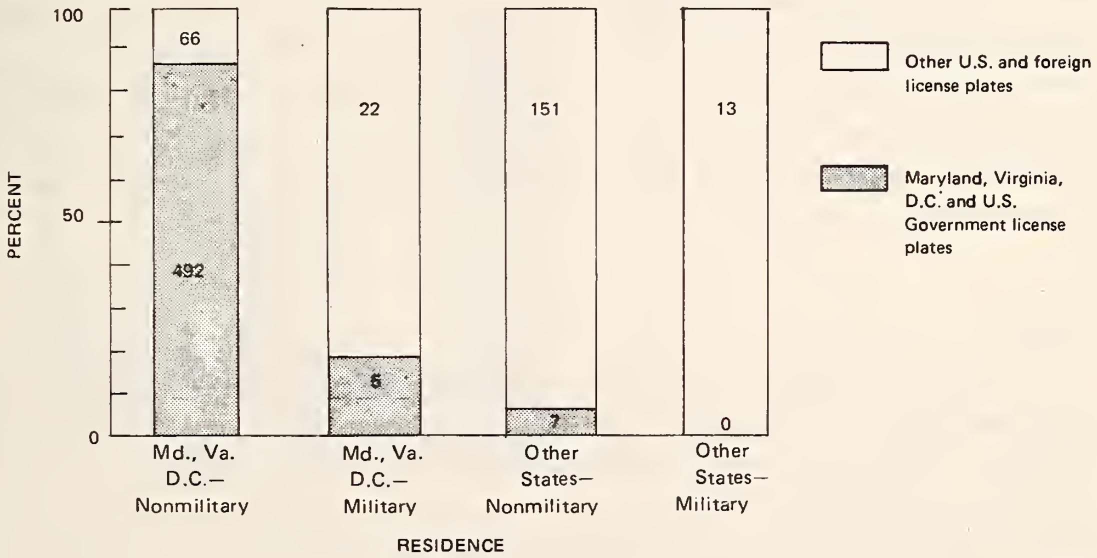

Figure 45. License plate and residence.

It can be seen that license plate and residence are generally congruent. As would be expected, a Chi-square test of these data is highly significant at the .001 level ($X^2 = 455.89$, df = 3). The relationship, however, is not perfect. Twelve percent of those civilians residing in Maryland, Virginia, or the District of Columbia carried license plates from other states. For those living on military bases in the local area, 81 percent bore plates from other states. Of those living in nonlocal states, four percent carried a Maryland, Virginia or District of Columbia license plate. The 13 respondents from other than local military bases all had nonlocal plates.

Familiarity

Figures 46 and 47 show familiarity (both frequency and recency of driving the route) against license plate. Chi-square tests are highly significant for both cross tabulations (frequency: $X^2 = 251.08$, df = 2, $p < .001$; recency: $X^2 = 154.78$, df = 2, $p < .001$). However, the relationships are not perfect, even at the extremes, as may be expected. For example, 21 percent of those who had never driven the route before had local license plates while 39 percent of those who had driven it at least six times bore nonlocal plates. Similarly, 19 percent of those who drove the route previously and within the last 30 days had nonlocal license plates.

Thus, in the manual coding of vehicles with the Traffic Evaluator System, some vehicles coded as local contain drivers who have not driven the route before. This error, however, is likely to be small. The larger error is with vehicles coded as nonlocal which are driven by drivers who are highly familiar with the route. License plate was thus a poor indicator of route familiarity (both in terms of recency and frequency). Unfortunately, the true magnitude of this error cannot be estimated since the relationship between respondent drivers (composed of exit, selected and thruput cases) and the population actually using I-495/I-70S is unknown. It is evident, however, that the license plates were definitely an inaccurate means of gauging route familiarity in this study.

Summary

Since the main purpose of this study is to delineate differences between conventional and diagrammatic signs, it is important to identify those which stand out in the cross tabulations of interview responses. Generally speaking, respondents both favored diagrammatics (93 percent) and felt that they were of greater aid to the average motorist. There is a strong suggestion, however, that an individual's experience with graphic signs is of importance. Personal preferences regarding diagrammatics were not found to be significantly related to either sex or age group. The

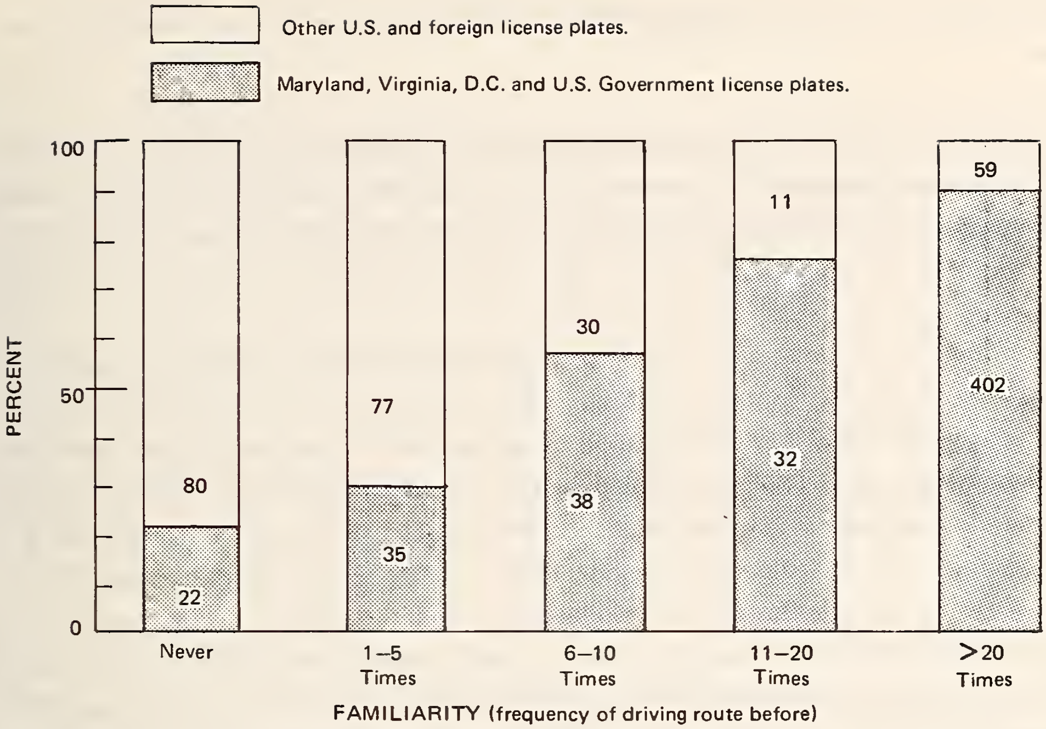

Figure 46. License plate and past frequency of driving route.

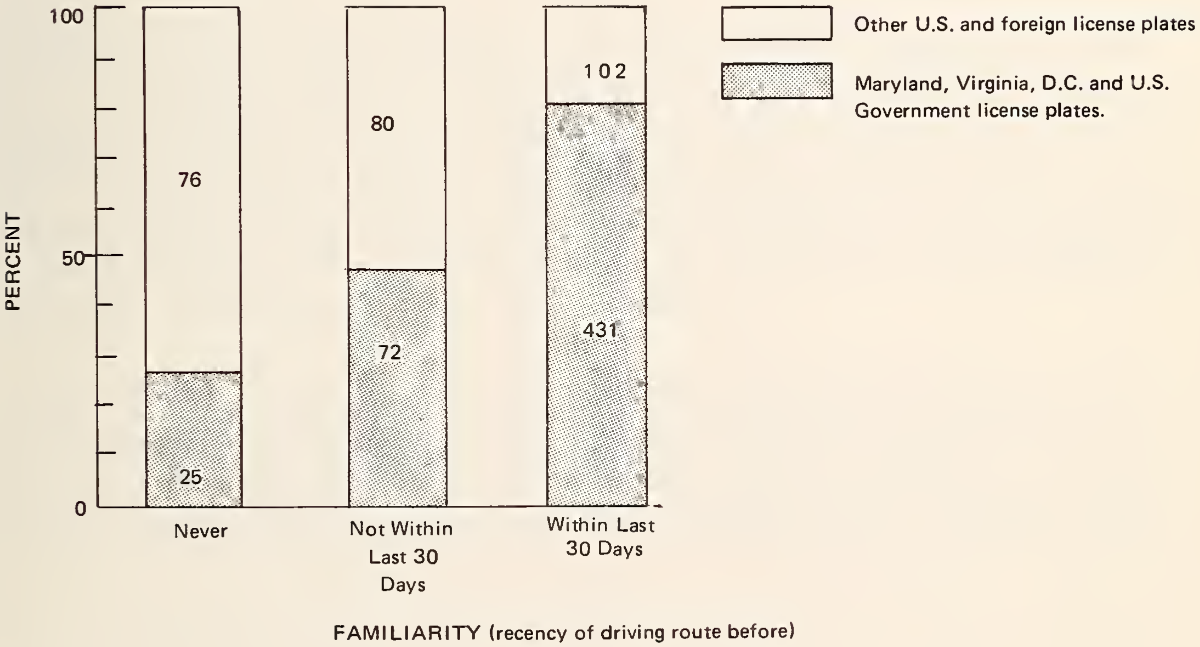

Figure 47. License plate and recency of driving route.

conclusions therefore may be generally considered valid across all strata of demographic driver classifications.

Differences were found in the percentages of drivers having difficulty with conventional and diagrammatic signs. Although the percentages were less with the graphic signing, generally the differences were not significant (for sex, age and route familiarity related to sign difficulty).

Since this project used the Traffic Evaluator System extensively in identifying traffic movement characteristics, it is interesting to note the relationship between license plate and residence as a check on the reliability and validity of manual coding. As was shown, there are a great number of drivers who claim a residency in the local area (Maryland, Virginia, or the District of Columbia) and who are thus relatively familiar with this area, but who have a license plate on their vehicle from another state. While the percentage of vehicles in this category for all traffic passing through the study area is indeterminable, the 39 percent with nonlocal license plates who had driven the route at least six times and the 39 percent of drivers with nonlocal plates who had driven it within the last 30 days who were manually coded as "foreigners," could help to account for the lack of highly significant differences between presumed local and nonlocal vehicles in the TES data.

Acclimation Phase Study[1]

Introduction

It will be recalled that the objective of the Acclimation phase study was to investigate the immediate impact of a change in signing on traffic behavior. A subpopulation of interest was local drivers, highly familiar with the route, who had developed an expectancy for the conventional signs along their way. Whether the new signs would be noticed by these motorists, whether the new signs would affect their performance, and if so, how long a performance change would persist, were key questions.

The direction of performance change, if a change occurred, was not considered predictable. Either improvements or decrements in performance, temporary or permanent, could be predicted depending upon the nature and degree of effect of the new signs and their information content compared to the old signs.

The reaction of drivers unfamiliar to the area was also of interest. Unfamiliar drivers in the Acclimation phase are no different from unfamiliar drivers in the Before/After study. In other words, the impact of the signing on those unfamiliar with the route should be similar to the effects of the diagrammatic signs on the same type of drivers in the Before/After study, assuming that traffic densities do not constrain the behavior of this group.

Unfortunately, however, Before/After study data already presented indicates that license plates are a very imperfect indicator of familiarity or unfamiliarity with the route in this area. Some highly familiar drivers have nonlocal plates and some drivers with local plates are quite unfamiliar with the test section. This undoubtedly obscured differences between the local and nonlocal subpopulations in the main Before/After study. Thus, the desired separation between these groups for TES data in the Acclimation phase is not to be expected (and Acclimation phase questionnaire data indicated that it was not found).

It is important to keep clearly in mind the differences between the Before/After and the Acclimation phase study designs. In the Before/After study, data collection periods at any given site were separated by one year. In the Acclimation phase, before and after data were separated by one day with follow-up data collection in succeeding weeks. A summary of the data collection effort is provided below as a framework for review of the results. The basic design of the data collection schedule was:

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[1] The contribution of Jerry Kidd in the data analysis and preparation of this section is gratefully acknowledged.

1. Collect baseline data on traffic behavior on Tuesday under the conventional signing condition.
2. Change signs from conventional to diagrammatic on Wednesday.
3. Collect data on traffic behavior on Thursday and Friday under the diagrammatic signing condition.
4. Collect follow-up data on Thursdays of succeeding weeks (not necessarily each week) for up to six weeks.

The Acclimation phase study was conducted at two interchanges, 17 North and 16 South. These interchanges were selected because Before phase observations suggested that of all the test interchanges, these were associated with the most driver difficulty. The major split at 17 North with two lanes exiting to the left as I-70S and two lanes continuing to the right as I-495 is simple in plan view but motorist behavior shows it to be associated with driver difficulty. Interchange 16 South is complex in plan view. In addition to two exit ramps, there is a lane drop at the second gore as shown in Figure 48. It should also be noted that the new signs at these two interchanges represented two extremes. For 17 North, the diagrammatics were not greatly larger than the conventional signs which had been installed at the same location, and the graphics were simple. For 16 South, the new signs were much larger than the old and the graphic in combination with the sign message was more complex.

All sign locations on the approach to these two interchanges were studied in the Acclimation phase. Thus, data were collected at the advance, exit direction and gore locations. Time-lapse photography, the TES and motorist response to a questionnaire were the data collection methods used.

Time-lapse films were made at the three guide sign locations of 17 North and the four guide sign locations of 16 South on Tuesday, Thursday and Friday of the week of signing change and on Thursdays of subsequent weeks. Films at all signing locations within a given interchange were made simultaneously. For 17 North, the last set of films was made six weeks after the week of signing change. For 16 South, the last set of films was made five weeks after the week of signing change.

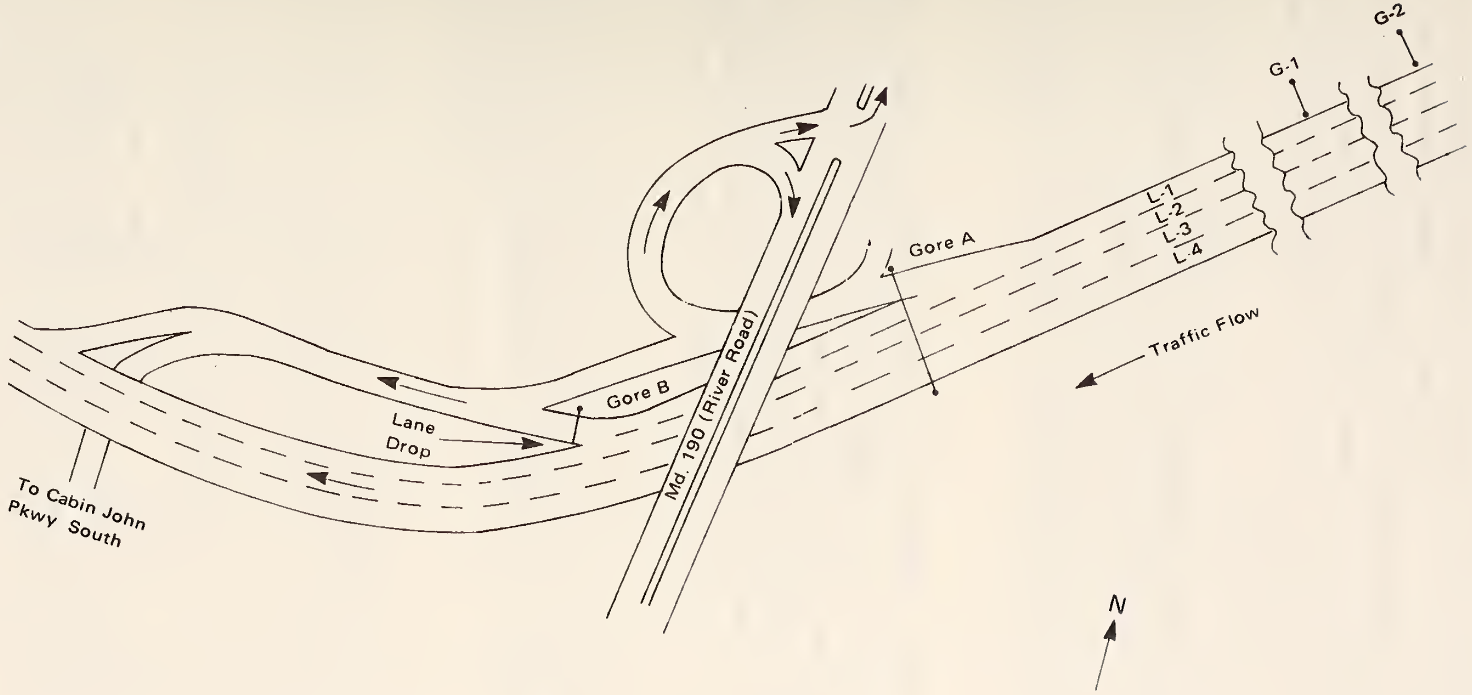


Figure 48. Simplified schematic representation of Interchange 16 South.

Reasons of expense and the fact that only two TES recorder systems were available restricted the use of the TES to selected sign locations and time intervals during the Acclimation phase study. At 17 North, TES data were collected at the gore location on Tuesday, Thursday and Friday of the week of signing change. At 16 South, TES data were collected at the first gore and at the advance sign location on Tuesday, Thursday and Friday of the week of signing change. TES data were also collected at these two sign locations of Interchange 16 South on the third Thursday after signing change.

Responses to the questionnaire distributed to motorists were obtained on Tuesday, Thursday and Friday of the week of signing change at both interchanges.

More detail on the schedule of data collection activities was presented in Chapter IV.

Time-Lapse Photography

In the following report of the results obtained with time-lapse photography, data collected during the Before phase of the main Before/After study are included for comparison purposes. It should be noted that, because all lanes could not be instrumented with the TES at 17 North and 16 South (the number of TES inputs is limited to 60), a complete picture of changes in traffic volume and vehicular movements could only be obtained with time-lapse films at these locations.

Traffic Volume

The average hourly volumes for the nonrush-hour traffic periods during the Before phase of the main Before/After study (designated in the table as Before-prime) and the volumes found in the Acclimation phase are shown below. The Before-prime data were obtained after Labor Day.

Table 12

Average Hourly Volumes Measured at Gore Areas

	Total Volume		Exit Volume		% Exiting	
Interchange	Before Prime	Acclimation	Before Prime	Acclimation	Before Prime	Acclimation
16 South	2359	2420	429	482	18.2	19.9
17 North	2097	2174	1048	1024	50.0	47.1

Collection of Acclimation phase data began in February at 17 North and in April at 16 South. The figures over the approximate six-month period separating the Before phase and Acclimation phase show a small change in exiting and total volume. Fluctuation in the proportion of exiting vehicles appears to be well within reasonable sampling tolerance. There is no marked difference in the traffic volume or route pattern from the baseline Before phase to the Acclimation phase for the two sites.

Primary Analysis of Vehicular Movements. Results at the signing locations studied are presented in the same order as the motorist approaching the test interchanges encounters the signs. Thus, results at advance and exit direction locations are presented first, followed by results at the gores. This order of presentation was selected because of the interest in identifying a novelty effect of the new signs. This effect would be expected to be largest at the first sign(s) encountered.

Four types of lane movements were scored at advance and exit direction sign locations: preparatory movements, through movements, other lane changes and double lane changes (movements across two lanes or more as in going from Lane 1 to Lane 3). Preparatory movements and through movements are defined in terms of expected behavior at the gore. Thus, at Interchange 17 North, a major fork interchange at which the left two of four lanes exit as I-70S, a preparatory movement is counted when any vehicle moves out of the two right lanes and enters one of the two left lanes. At Interchange 16 South, as at all other interchanges studied, the exits are right-hand off ramps. Preparatory movements at advance and exit direction sign locations for right exit interchanges are movements into the right lane. Preparatory movements are thus movements which are hypothesized to indicate that the driver is intending to exit at the interchange.

Through movements are the opposite of preparatory movements. Thus, at the advance and exit direction signs for 17 North, they are movements into one of the two right-hand lanes. For 16 South, through movements are movements out of the right-most lane. The hypothesis underlying the term "through movement" is that these movements are made by drivers who recognize that exiting at the interchange is not on the way to their destination. Thus, they leave the lane associated with exiting and generally slower moving traffic.

Other lane changes are all lane changes not classed as preparatory or through movements. Double movements, those involving a change of more than one lane within the zone scored, are included with the preparatory, through and other category as appropriate but are also tabulated separately.

Each of the above categories of advance and exit direction movements was divided by the total traffic volume at the site and expressed as movements per 1000 vehicles. Results are shown in Tables 13 through 16 . In these tables, the row headings show the period of observation. Thus, the top row in each table provides the baseline established in the Before phase of the main Before/After study conducted in the Fall of 1971 (Before, Prime). The Acclimation phase data are shown in successive rows in chronological order. The second row heading (Before, Acclimation) refers to data collected on the day before the signs were changed. Subsequent row headings show data collected after the signs were changed. The day the signs were changed to diagrammatics was designated "D". Thus, the first day of data collection on the first day after the signs were changed is designated D_1.

Table 13

Lane Movements Per 1000 Vehicles at the 16 South Advance (G-2) Sign

Interchange	Sign	Period	Prep 1000	Thru 1000	Other 1000	Total 1000	2 or More 1000
16S	G-2	Before Prime	8.6	11.8	32.0	52.4	1.8
		Before Acclimation	14.3	18.8	36.4	69.5	5.7
		After D_1	18.2	27.9	65.1	111.0	7.1
		After D_2	12.4	23.2	44.4	79.9	4.8
		After D_1 + 3 wks	8.1	27.7	36.2	72.0	6.3
		After D_1 + 5 wks (1400 only)	8.7	30.0	33.2	71.9	3.9

Table 14

Lane Movements Per 1000 Vehicles at the 16 South Exit Direction (G-1) Sign

Interchange	Sign	Period	Prep 1000	Thru 1000	Other 1000	Total 1000	2 or More 1000
16S	G-1	Before Prime	11.6	6.9	28.6	47.1	0.6
		Before Acclimation	17.3	10.2	30.1	57.5	0.9
		After D_1	13.9	9.2	30.9	54.0	2.6
		After D_2	12.5	8.7	29.1	50.4	1.1
		After D_1 + 3 wks	15.2	7.0	34.1	56.7	1.7
		After D_1 + 5 wks (1400 Only)	9.8	17.1	35.9	62.8	4.1

Table 15

Lane Movements Per 1000 Vehicles at the 17 North Advance (G-2) Sign

Inter-Change	Sign	Period	Prep 1000	Thru 1000	Other 1000	Total 1000	2 or More 1000
17N	G-2	Before, Prime	19.6	18.6	40.1	78.4	3.9
		Before, Acclimation	24.9	15.3	56.1	96.3	3.8
		After, D_1	24.3	15.2	40.6	80.1	-0-
		After, D_2	22.0	17.6	44.6	84.2	3.5
		After, D_1 + 3 wks	31.1	19.6	47.1	97.8	10.8
		After, D_1 + 5 wks	25.6	39.6	46.7	111.9	7.0

Table 16

Lane Movements Per 1000 Vehicles at the 17 North Exit Direction (G-1) Sign

Inter-Change	Sign	Period	Prep 1000	Thru 1000	Other 1000	Total 1000	2 or More 1000
17N	G-1	Before, Prime	13.3	44.4	66.6	124.3	9.9
		Before, Acclimation	13.6	39.8	64.8	117.8	6.3
		After, D_1	7.3	32.0	63.8	103.1	5.1
		After, D_2	10.4	25.0	67.8	103.2	3.1
		After, D_1 + 2 wks	8.7	33.8	57.1	99.6	5.8
		After, D_1 + 3 wks	5.7	24.5	58.1	88.3	3.3
		After, D_1 + 4 wks	6.3	35.4	68.9	110.6	3.6

A quick inspection of Tables 13 through 16 indicates that, with a few minor exceptions, the data are very stable. This is particularly apparent in Table 14 prepared for the exit direction (G-1) sign location at Interchange 16 South. The total (all lane changes per 1000 vehicles) shows a range from 47.1 to 62.8 over a six-month time span, with a strong clustering effect around 55 maneuvers per 1000 vehicles.

Turning attention to gross anomalies in the data, there appears to be an anomaly for the G-2 area at Interchange 16 South. The gross frequency of each of the various kinds of lane change maneuvers shows a marked peak on the first day after the change from conventional to diagrammatic signs. On subsequent days, the frequency of maneuvers declines again toward the level recorded immediately before the sign change. This pattern suggests that motorists reacted to the new sign configuration at first but that on repeated exposures tended to revert to well established behaviors (habit). It is interesting to note that this fact is found only at the advance sign; that is, at the first sign encountered by the motorist approaching Interchange 16 South. No effect was found at the exit direction sign which the motorist next encountered. At Interchange 17 North, on the other hand, no effect was found at either the advance or exit direction signs. It should be remembered, however, that the change in signing at Interchange 16 South was rather more dramatic than that at 17 North (see pictures in Chapter III). The new signs were much larger and the graphic was relatively complex at 16 South compared to those at other test interchanges including 17 North. Of all the interchanges studied, a novelty effect would be most expected at Interchange 16 South.

This level of examination suggests strongly that the change in signs had little overall effect on driver behavior for guide signs in advance of the gore except for the possibility that drivers tended to make more frequent anticipatory maneuvers for a short time after the signs were changed at Interchange 16 South.

For analysis at gore areas, each area was divided into zones. At Interchange 16 South (Table 17), there are three zones. Zone 3 begins at the tip of the painted gore and extends 300 feet downstream while Zone 2 extends the same distance upstream from the tip of the gore. Zone 1 extends another 300 feet upstream.

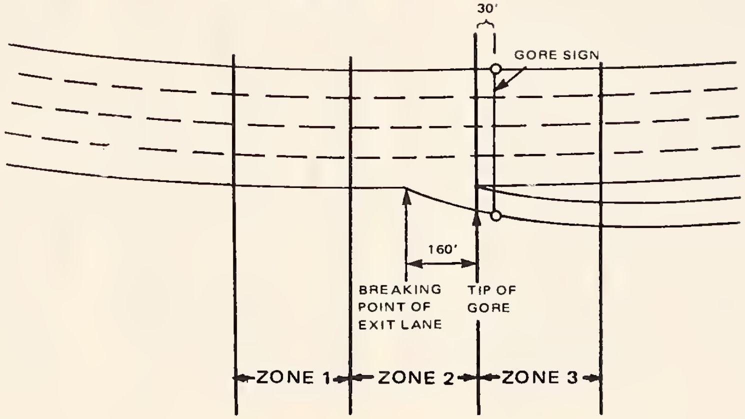
Lane change maneuvers are categorized by risk level. Four types of maneuvers have been defined. *Risk movements* are scored in Zone 1 and are movements into the right-most lane. Risk movements are scored for exiting vehicles only and expressed per 1000 vehicles. The rationale is that exiting vehicles should already be in Lane 1 by the time Zone 1 is reached. *High risk movements* are scored in Zone 2. They are the same movements as were scored in Zone 1 but since these movements occur so close to the gore, they are considered more hazardous and much more indicative of a last minute decision to exit. *Gore weaves* are movements scored in Zone 3 in which vehicles cross the painted gore in order to exit. They are measured for exiting vehicles only and expressed per 1000 exiting vehicles. *Exit returns* are movements across the painted gore from the exit ramp to return to the through traffic stream.

Table 17

Frequencics of Maneuvers Per 1000 Vehicles by Zone at Interchange 16 South

		Zone 1		Zone 2		Zone 3	Zone 2,3	Zone 3	Zone 1-3
Inter-		Risk	Lane Chge	High Risk	Lane Chge	Gore Weave	Exit Return	Lane Chge	All Moves
Change	Period	1000 Exit	1000 Thru	1000 Exit	1000 Thru	1000 Exit	1000 Thru	1000 Thru	Tot Vol
16S	Before Prime	36.8	44.8	5.8	58.7	2.9	0.8	65.4	93.6
	Before Acclim.	43.2	38.5	4.1	33.8	2.1	1.1	53.3	70.9
	After D_1	32.0	36.9	-0-	32.3	8.7	1.6	30.3	47.5
	After D_2	32.8	31.9	4.1	31.6	4.7	-0-	40.1	51.9
	After D_1 + 3 wks	24.1	33.6	2.7	51.3	-0-	-0-	44.1	66.3
	After D_1 + 5 wks	34.0	33.0	8.5	46.0	4.2	3.0	46.0	70.1
	1400 Only								

Exit 16S Gore



Exit returns are expressed per 1000 through vehicles. Besides the above maneuvers, *lane changes* of through traffic are counted in the zones and expressed per 1000 through vehicles. An overall summary measure is provided in the last column of Table 17 which is the sum of risk maneuvers, high risk maneuvers, gore weaves, exit returns and other lane changes expressed per 1000 total traffic volume.

Similar logic was followed in Table 18 for Interchange 17 North except that the very different geometry of this interchange requires that the maneuvers be differently defined. Two larger zones were selected. Zone 1 covers the gore extension line, the solid stripe of white paint separating the two left lanes from the two right lanes and extending from the painted gore upstream. The length of this line is 490 feet. Zone 2 begins at the tip of the painted gore proper and continues downstream to the beginning of a guard rail in the gore, a distance of 540 feet. It should be noted that there are channelization arrows on the road surface at this interchange to direct traffic. Movements across the gore extension line or the painted gore (Zones 1 and 2, respectively) are technically violations although motorists are rarely, if ever, stopped for such violations. Movements in the two zones defined are presented separately. Lane changes across the painted gore are, of course, considered more hazardous than those across the extension line.

The following measures are presented for Interchange 17 North in Table 18:

- Movements into the left two lanes across the gore or the gore extension line. These are expressed as weaves left per 1000 *exiting* vehicles.
- Movements into the right two lanes across the gore or its extension line. These are expressed as weaves per 1000 *through* vehicles.
- All other lane changes which do not involve crossing the painted gore or its extension line. These are expressed as *other* per 1000 total vehicles.

The sum of weaves left, weaves right and other lane changes equals all the lane changes in each zone. This is expressed as *total* changes per 1000 total vehicles in each zone. The last column for Interchange 17 North shows the total lane changes across both zones per 1000 *total* vehicles.

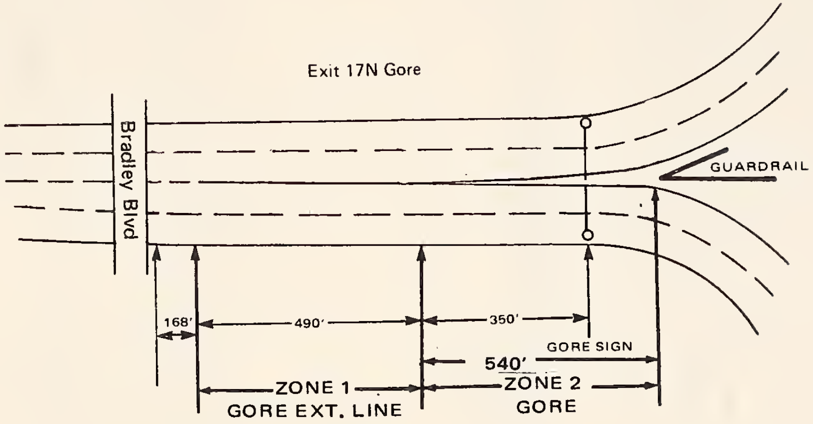
If the data are examined at the same level as used in the review of the findings at the advance and exit direction signs, the picture which emerges is comparable. There is a suggestion of a reduction in risk maneuvers (Zone 1) for Interchange 16 South and of weaves to the right across the gore extension line for Interchange 17 North. Likewise, weaves to the right in the gore area proper at Interchange 17 North decline in what appears to be a consistent trend.

Table 18

Frequencies of Maneuvers Per 1000 Vehicles by Zone at Interchange 17 North

		Gore Ext. Line				Gore				Both
Inter-	Period	Weave Left	Weave Rt	Other	Total	Weave Left	Weave Rt	Other	Total	All
Change		Exits	Thru	Total	Tot Vol	Exits	Thru	Total	Tot Vol	Tot Vol
17N	Before Prime	17.6	28.1	28.4	51.3	16.3	27.9	26.5	48.6	99.8
	Before Acclimation	11.3	22.5	24.2	41.3	8.6	18.5	26.2	39.9	81.2
	After D_1	11.9	21.3	23.4	40.2	11.9	8.7	29.2	39.3	78.5
	After D_2	13.3	14.8	29.5	43.2	12.3	14.2	26.8	40.0	87.4
	After D_1 + 2 wks	12.5	19.6	28.8	45.1	16.7	5.3	33.6	44.2	89.3
	After D_1 + 4 wks	13.3	15.2	31.4	45.7	5.7	3.4	31.4	35.8	81.6

Exit 17N Gore



Because these findings are suggestive and are congruent with conceptualizations of the kinds of errors that motorists can most easily make at these interchanges, these data require more detailed analysis. Unfortunately, the data do not lend themselves to conventional statistical treatment because of the small sample sizes. The most tenable approach is to employ a simple Chi-square analysis of the raw data; recognizing that no exact specification of statistical significance is possible.

With these constraints in mind, attention is returned to the phenomenon suggested by the data for the advance (G-2) sign at Interchange 16 South. Here, the frequency of preparatory maneuvers on the day before the sign was changed was 14.3 per 1000 vehicles and on the day after it was 18.2 per 1000. The Chi-square test yields a value of 0.46 which would be exceeded for these kinds of data about 50 percent of the time by chance. In other words, the difference is not significant even by this crude test.

Accordingly, the hypothesized effect was sought in a more extreme form. Looking at the traffic for the 1400-1430 observation period and aggregating all single lane changes, the following effect results.

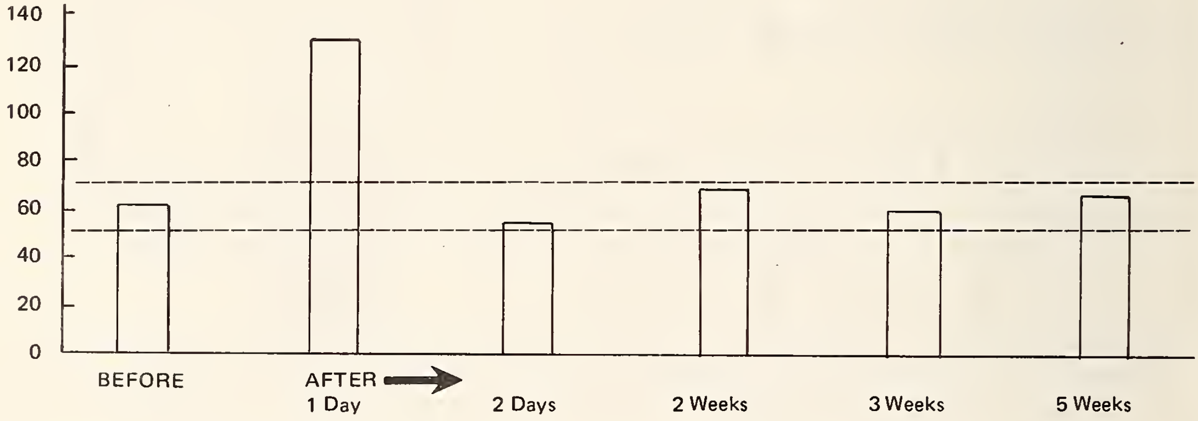


Figure 49. General lane changing activity in movements per 1000 vehicles (16S, G-2, 1400 hrs).

A comparison of the day before and the first day after sign change yields a Chi-square value of 13.68 which is highly significant ($df = 1, p < .001$). On subsequent days, however, as revealed in the diagram, the maneuver rate subsides to the baseline level.

It might be hypothesized that if the sign change induced an increase in maneuvering at the G-2 signing location, then there should be a decline in maneuvering at downstream locations. In other words, the motorist, having made his adjustment early on the basis of adequate information would have no need for further maneuvers. In a very gross way, this hypothesis is confirmed by Figures 50 through 52 and summarized in Figure 53. Figure 53, however, shows that the effect was quite transient. By three weeks after the signs were changed, the profile of maneuver frequencies looks more like the before condition than it resembles the outcome on the first day after the change in signs.

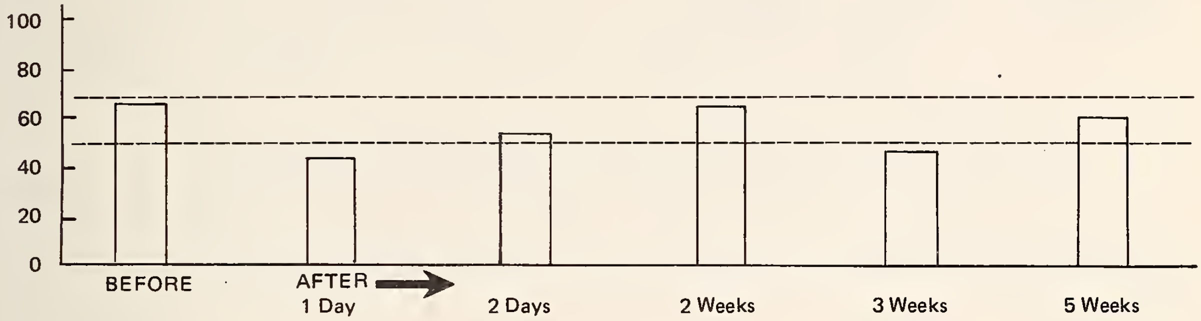


Figure 50. General lane change activity maneuvers in movements/1000 vehicles (16S, G-1, 1400 hrs).

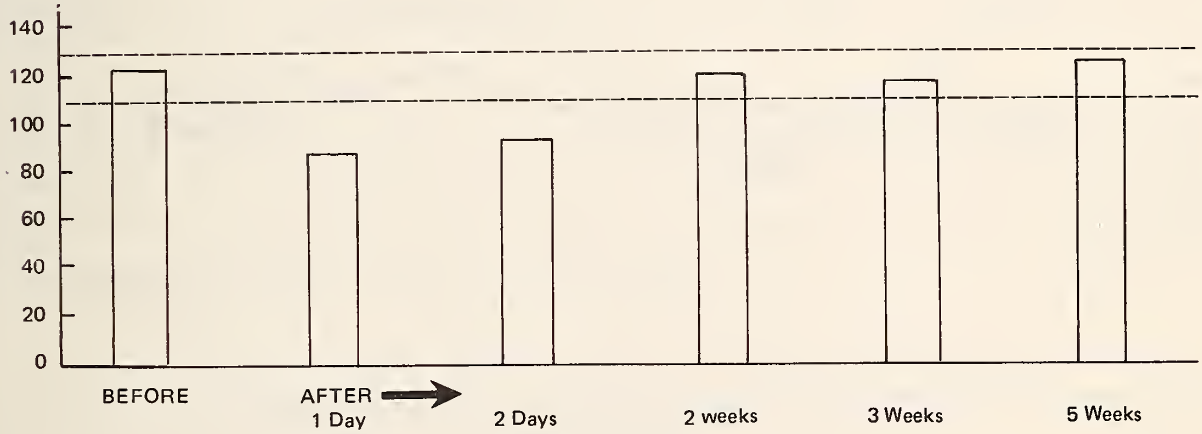


Figure 51. General lane change activity in movements/1000 thru vehicles (16S, first gore, 1400 hrs).

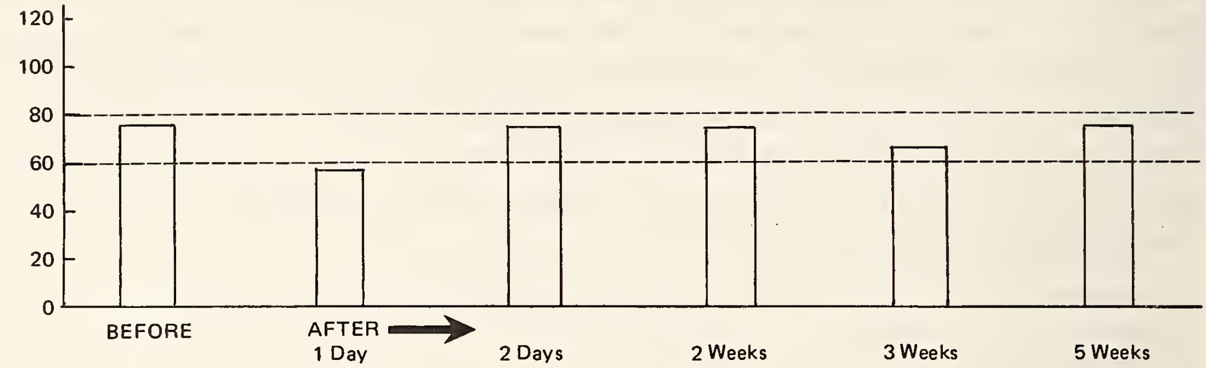


Figure 52. General lane change activity in movements/1000 thru vehicles (16S, second gore, 1400 hrs).

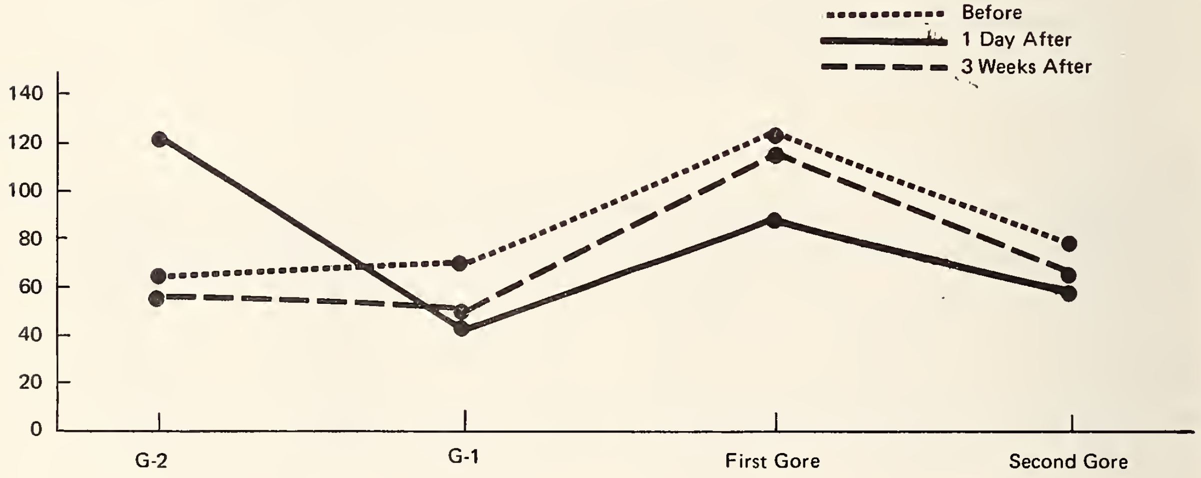


Figure 53. Gross lane change behavior in movements/1000 vehicles (16S, 1400 hrs).

The most consistent change discernable at Interchange 16 South involves a comparison of the aggregate lane changing frequency in Zone 2 of the second gore. This is the last 300 feet before the lane drop occurs.

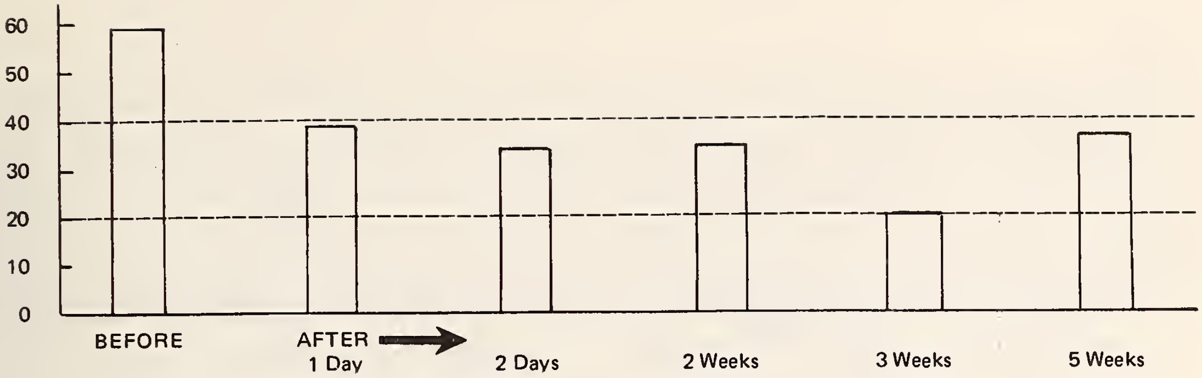


Figure 54. Last-minute lane changes in movements/1000 vehicles (16S, second gore).

The gross frequency falls from nearly 60 per 1000 on the day before the signs were changed to around 40 per 1000 on the first day after the change *and* the frequency tends to stay relatively low during the five week span of postchange observations. A rough Chi-square test comparing the day before to the day after yields a value of 4.0 which is likely to be exceeded only five percent of the time by chance.

Insofar as the data from Interchange 16 South is concerned, this finding is the only instance in which a "favorable" effect was found which was sustained over time. The effect at the advance location was, at best, transient and, at worst, an artifact or chance fluctuation.

Turning attention to Interchange 17 North, the most encouraging datum is the reduction in weaves to the right in the gore area proper. This again shows a decline which tends to remain below the baseline over several weeks. Since it is the left two lanes which exit and the right two lanes which must be used by traffic continuing on I-495, the positive effect of the signs is on the through traffic rather than on the exiting traffic.

A Chi-Square comparison of the before and immediately after findings was made and a value of 3.42 was obtained. The p value is .07 and consequently the difference does not reach the generally accepted significance levels (.05 or better).

A slightly more optimistic outcome is achieved by aggregating weaves to the right across the gore extension line and across the gore and then comparing the before datum to the average of the observations made after the sign change. In this comparison, there is a drop from 41 cases per 1000 to an average of about 25 cases per 1000 which yields a Chi-square value of 3.6 (insignificant at accepted levels). A graphic picture is illuminating.

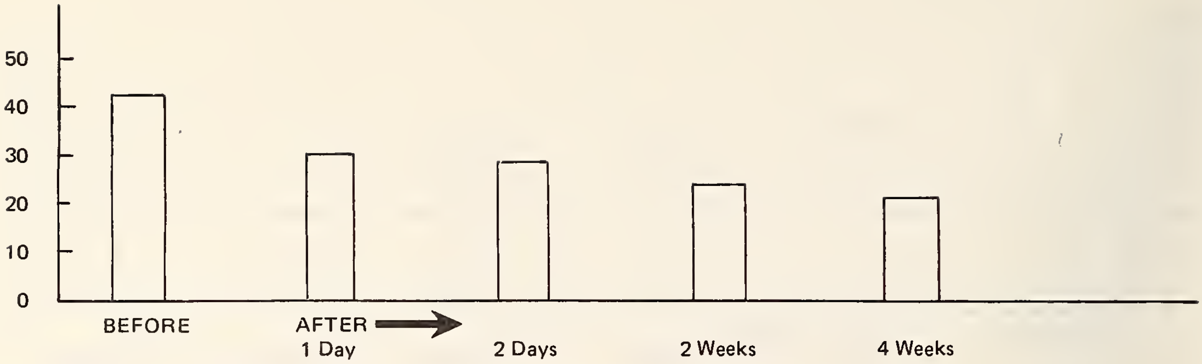
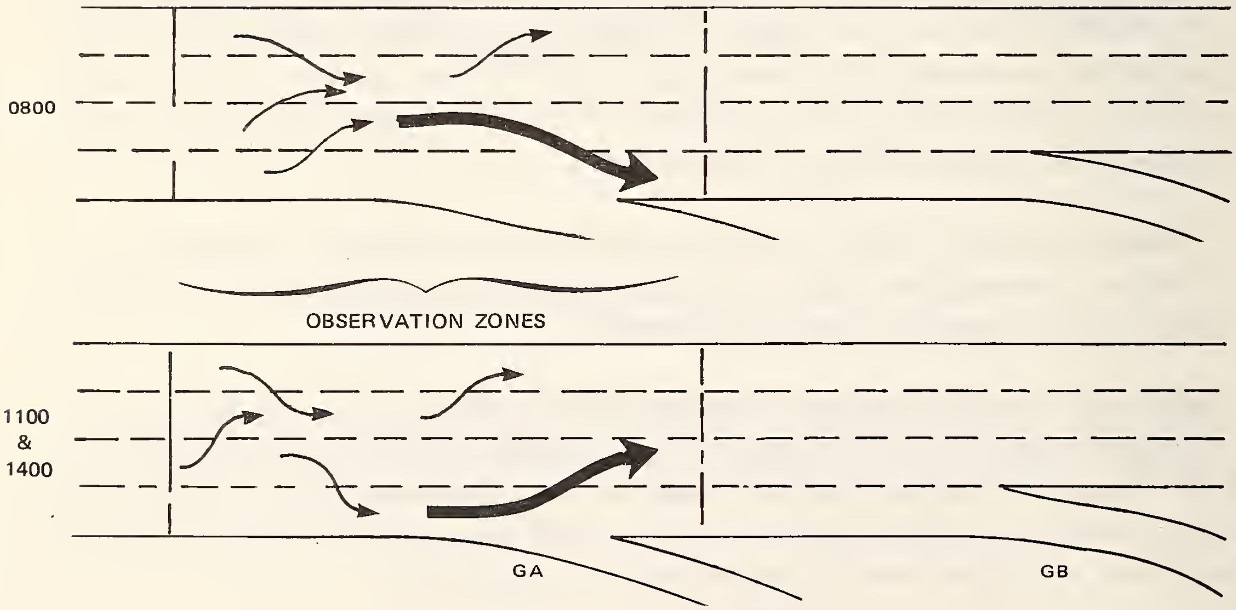


Figure 55. Composite of illegal rightward maneuvers at 17 North interchange (movements per thousand).

There is a consistent decline in illegal rightward maneuvers across the painted gore and its extension line at 17 North during the span of observations. While not very convincing from a strict statistical standpoint, it is suggestive of a persistent beneficial effect from the sign modifications.

Finally, to return again to Interchange 16 South, the photographic data revealed one interesting, if incidental, phenomenon. During rush-hour conditions, there is a very heavy movement of vehicles into the shoulder-most lane immediately subsequent to the gore at the first exit. These are presumably commuters on their way downtown via Cabin John Parkway. In the nonrush periods, the most frequent maneuver is the opposite one; namely, leftward out of the shoulder-most lane. These are presumably motorists avoiding the lane drop at the second exit.



In summary, it is noteworthy that the sign modifications had little or no discernable effects on rush hour traffic as measured by time-lapse photography. The effect of diagrammatic guide signs on nonrush period traffic is generally but marginally beneficial in the form of a moderate reduction in the frequency of hazardous, illegal maneuvers in the vicinity of the lane drop at the second gore. This imputed benefit, however, cannot be convincingly confirmed by statistical testing procedures. In addition, during the Acclimation phase, it should be recalled that the addition of an EXIT ONLY panel to the sign at the first gore confounded the results. This panel was not present under the conventional signing condition, nor was it present in the After phase of the Before/After study. The main Before/After study also showed a small benefit at the second gore without the confounding presence of this additional EXIT ONLY panel.

Traffic Evaluator System

Interchange 17 North. Data were taken at Interchange 17 North at the gore area on three days, the day prior to the change in signing and the two days immediately after. Data were taken during rush hour (0800 to 0900) and during the nonrush period (0930 to 1430) on all three days. However, as a result of technical difficulties, the third day of data for the rush period could not be used.

In general, TES data collected during rush hour confirm the findings of the photographic record in that the impact of modification of the guide sign on this traffic was relatively slight. Rush-hour traffic is largely composed of drivers who are repeated users of the interchange and who are familiar with its peculiarities. Thus, almost all the detail-level measures in Table 19 show no significant change. However, the composite measure of speed difference, headway violation and hazardous maneuver *does* show a significant decrement on the first day after the sign change *and* a general improvement is indicated by the significant increase (from circa 57 percent, before, to circa 62 percent, after) in the proportion of normal traffic. This finding justifies a look at the hazardous maneuver data in more detail.

Figure 56 presents the more detailed figures for convenient inspection. In all instances, except for very hazardous maneuvers to the right across the gore, the *direction* of change is one which favors the modified guide signs.

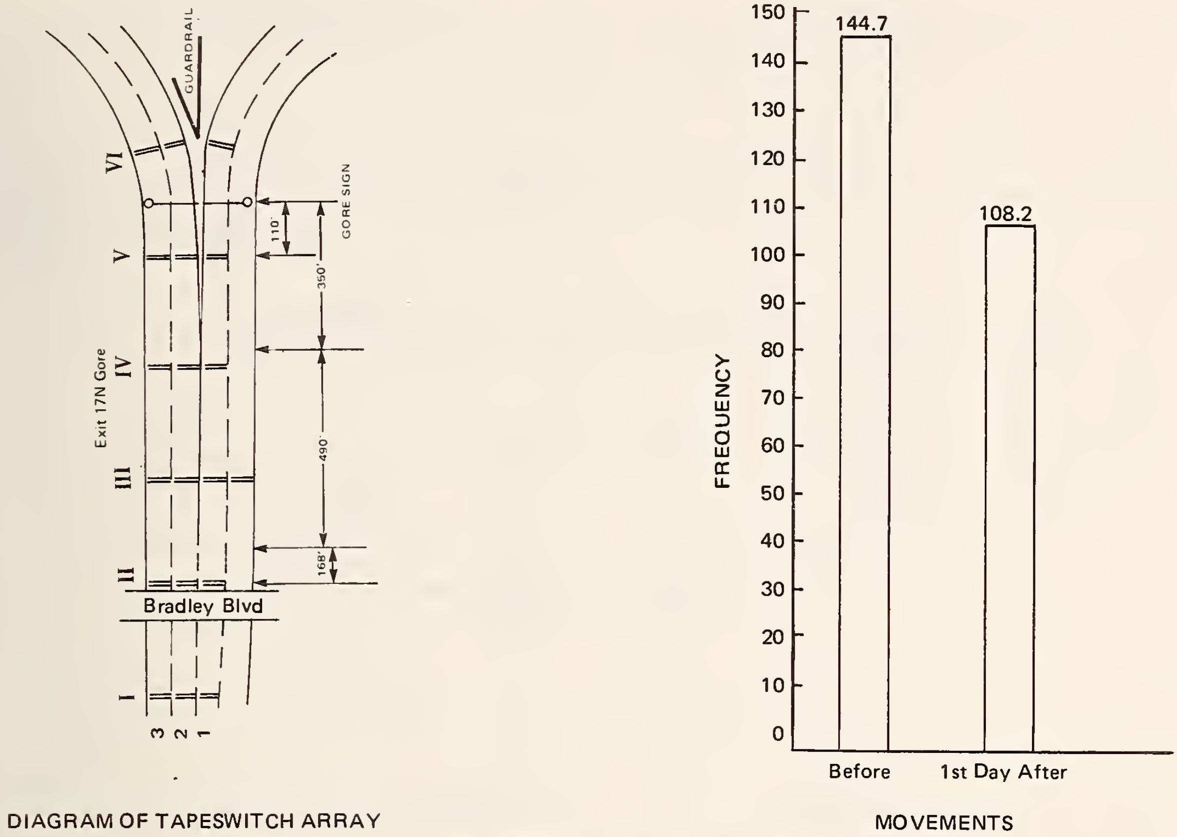
Table 19

Proportion of Vehicles Meeting Various Criterion Measures at 17 North (rush hour)

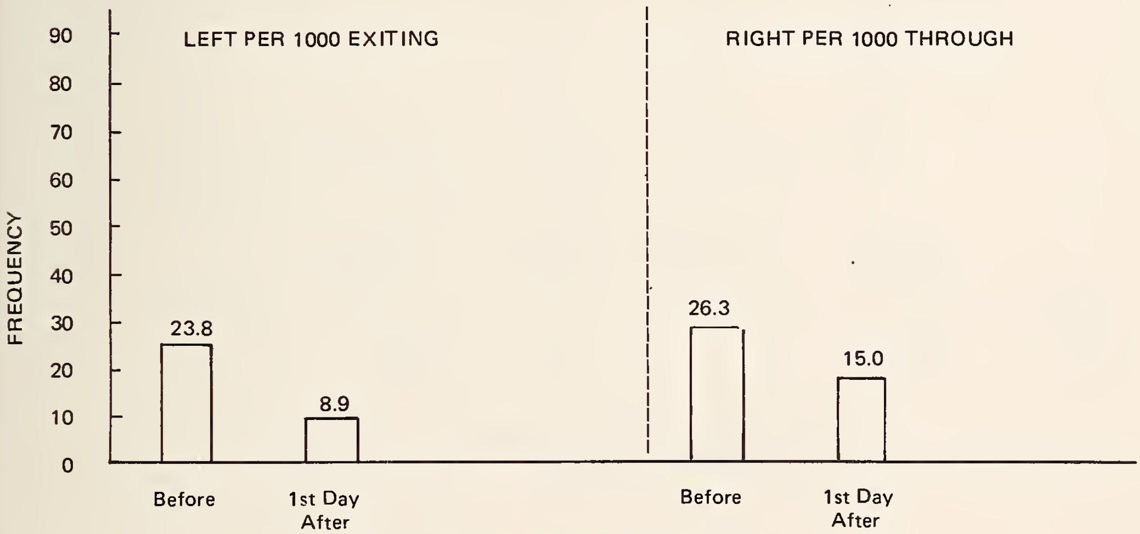
INTERCHANGE 17 NORTH
GORE SIGN (BEFORE)
2/8/72
0800-0900

INTERCHANGE 17 NORTH
GORE SIGN (AFTER)
2/10/72
0800-0900

	AUTOS	AUTOS	NONAUTOS	NONAUTOS	ALL	ALL
	2260	2293	83	54	2343	2347
1. SPEED DIFFERENCE	.10044 .01239	.09071 .01176 N.S.	.22692 .09039	.27778 .11947 N.S.	.10499 .01241	.09501 .01186 N.S.
2. HEADWAY VIOLATION	.20133 .01653	.18360 .01585 N.S.	.08434 .05979	.09259 .07731 N.S.	.19718 .01611	.18151 .01559 N.S.
3. HAZARDOUS MANUEVERS	.01504 .00502	.01221 .00450 N.S.	0.00000 0.00000	0.00000 0.00000	.01451 .00484	.01193 .00439 N.S.
4. 1 + 2	.08053 .01122	.07021 .01046 N.S.	.16867 .08056	.09259 .07731 N.S.	.08365 .01121	.07073 .01037 N.S.
5. 2 + 3	.01106 .00431	.01352 .00473 N.S.	.02410 .03299	0.00000 0.00000	.01152 .00432	.01321 .00462 N.S.
6. 1 + 3	.00752 .00356	.00436 .00270 N.S.	.01205 .02347	0.00000 0.00000	.00768 .00354	.00436 .00264
7. 1 + 2 + 3	.01239 .00456	.00611 .00319 ↓	.02410 .03299	.01852 .03596 N.S	.01280 .00455	.00639 .00322 ↓
8. NORMAL	.57168 .02040	.61928 .01987 ↑	.45783 .10719	.51852 .13327 N.S.	.56765 .02006	.61696 .01967 ↑
9. DBL LANE CHANGES	.01770 .00544	.01832 .00549 N.S.	.01205 .02347	0.00000 0.00000	.01750 .00531	.01790 .00538 N.S.

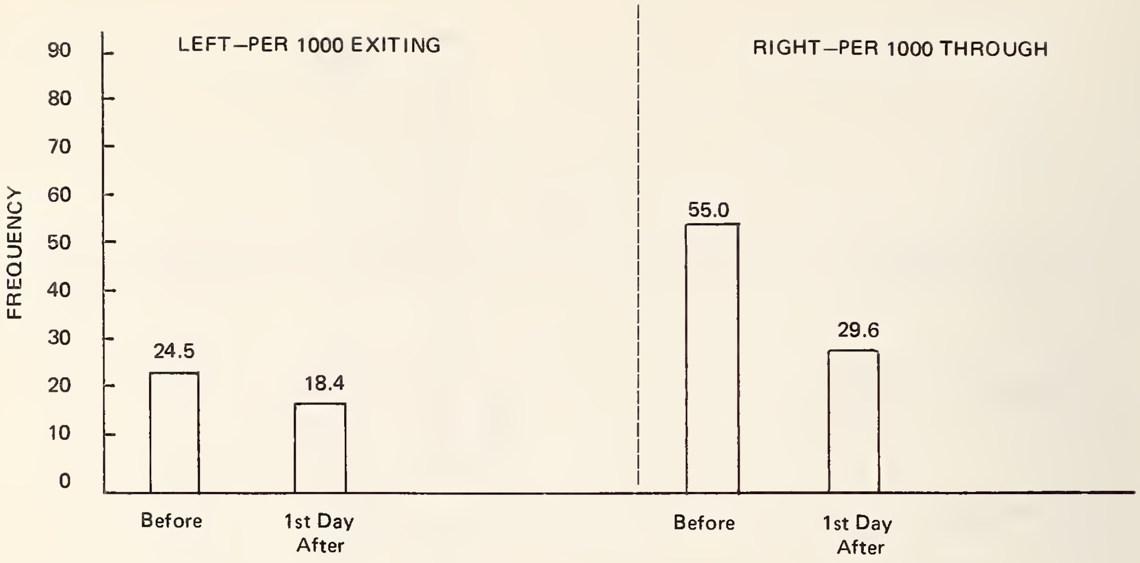


A. General Turbulence — Lane changes between all traps per 1000 vehicles

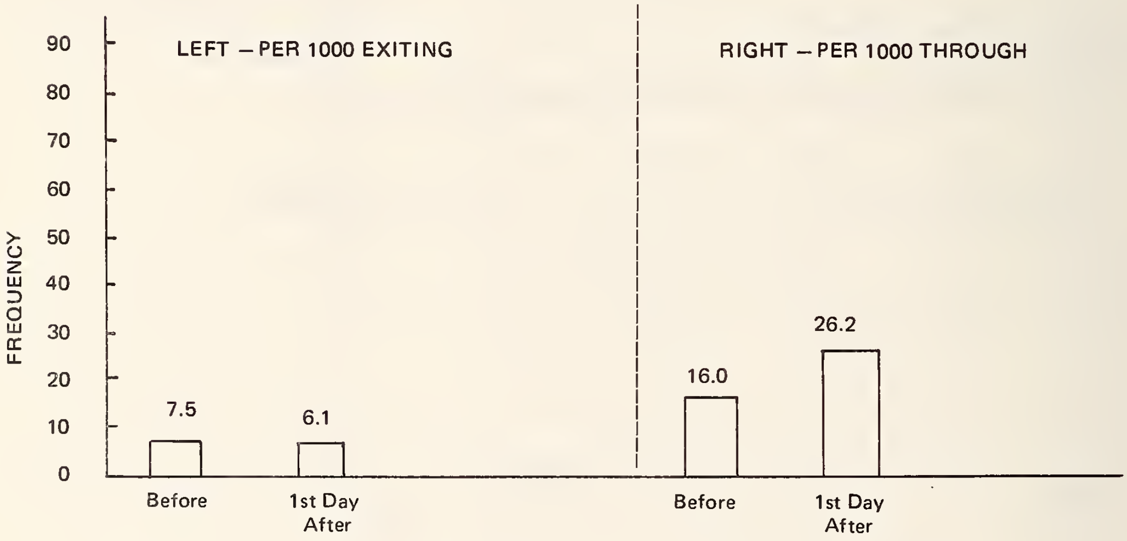


B. Movements across the projection of the extension line (Between Traps 1 and 2)

Figure 56. Rush hour traffic at Interchange 17 North during the Acclimation phase.



C. Hazardous maneuvers — across extension line
(Between Traps 2 and 4)



D. Very hazardous maneuvers — across Gore
(Between Traps 4 and 6)

Figure 56 (Cont'd.). Rush hour traffic at Interchange 17 North during the Acclimation phase.

As expected on the basis of the photographic findings, the nonrush period traffic is somewhat more sensitive to the effect of the changes in signing. The effects could not be attributed to the influence of nonlocal drivers as shown below. Nearly all changes are insignificant. The nonlocal population was identified by manual code inputs to the TES as described in Chapter IV. The small sample size results from extremely cold weather which restricted manual coding to one hour.

Hazard Indicators on Sub-Sample of Non-Local Vehicles
in the Gore Area of Interchange 17-North, Acclimation Phase

		2/8/72 160	2/10/72 175		2/11/72 207	
1.	SPEED DIFFERENCE	.20000 .06198	.16000 .05432	N.S.	.24638 .05870	N.S.
2.	HEADWAY VIOLATION	.07500 .04081	.08571 .04148	N.S.	.06763 .03421	N.S.
3.	HAZARDOUS MANUEVERS	.01875 .02102	.02286 .02214	N.S.	.05314 .03056	↑
4.	1 + 2	.05000 .03377	.02857 .02468	N.S.	.06280 .03335	N.S.
5.	2 + 3	.00625 .01221	0.00000 0.00000		.00966 .01333	N.S.
6.	1 + 3	.02500 .02419	.03429 .02696	N.S.	.03382 .02462	N.S.
7.	1 + 2 + 3	.00625 .01221	.00571 .01117		.00966 .01333	N.S.
8.	NORMAL	.61875 .07526	.66286 .07004	N.S.	.51691 .06808	↓
9.	DBL LANE CHANGES	.00625 .01221	.02286 .02214	N.S. --	.02899 .02285	

The Before/After study questionnaire data showed that license plates are a poor index of unfamiliarity and the questionnaire data collected in this phase (reported later) confirmed this. It is unfortunate that license plates were such a poor indicator.

Table 20 indicates a drop in speed anomolies, combined speed-headway violations and combined speed-hazardous maneuvers on the first day after sign change but these effects are contradicted on the second day. The second day shows a significant increase in most indicators but a drop in hazardous maneuvers compared to the day before the sign change. There is also a significant increase in the level of normal flow on the second day after sign change.

At the level of detailed analysis of maneuvers, general turbulence fell from circa 174 moves per thousand vehicles to circa 123 on the first day after and 154 on the second day after. Movements over the projection of the extension line between Traps 1 and 2 to the left were 12.1, 9.3 and 17.8 for the before, first day after and second day after, respectively. To the right they were 21.2, 20.5 and 24.2 in the same order. Movements over the extension line to the left between Traps 2 and 4 were 37.4, 22.6 and 40.3; those to the right were 53.5, 58.5 and 65.3. Gore weaves (between Traps 4 and 6) to the left were 14.2, 10.9 and 6.2. Gore weaves to the right were 36.3, 28.3 and 29.2, respectively. Again, the effects, if any, appear to be quite transient.

This is further illustrated by the lane placement data in Figure 57 which shows the distribution of through traffic across the array at the gore over successive days. The data show a small reduction in the proportion of vehicles in the wrong lane for continuation on I-495 but the data are generally not statistically significant.

The same was true of exiting traffic as shown in the same figure. There is a small but significant decrease in vehicles entering the array in Lane 1 on both days after the signing change. There is also a small but significant decrease in the number of vehicles in Lane 3 both entering and exiting the array. It will be noted that the more even distribution of vehicles in the two exit lanes seen in the After phase of the main Before/After study was not found in the after phase of the Acclimation study. Indeed, the opposite is true. The exiting vehicles are less evenly distributed than they are on the day immediately preceding the signing change. Whether this is due to a novelty effect associated with a performance decrement on the part of familiar drivers or some other cause is unknown.

Table 20

Proportion of Vehicles Meeting Various Criterion Measures at 17 North (Nonrush Hours)

INTERCHANGE 17 NORTH
GORE SIGN (BEFORE)
2/8/72
0930-1430

INTERCHANGE 17 NORTH
GORE SIGN (AFTER)
2/10/72
0930-1430

INTERCHANGE 17 NORTH
GORE SIGN (AFTER)
2/11/72
0930-1430

		AUTOS	AUTOS	AUTOS	NONAUTOS	NONAUTOS	NONAUTOS	ALL	ALL	ALL
		4976	5403	7450	242	322	488	5218	5725	7938
1.	SPEED DIFFERENCE	.15896 .01016	.13622 .00915 ↓	.20523 .00917 ↑	.32231 .05888	.36025 .05244 N.S.	.40164 .04350 ↑	.16654 .01011	.14882 .00922 ↓	.21731 .00907 ↑
2.	HEADWAY VIOLATION	.08501 .00775	.08847 .00757 N.S.	.10510 .00696 ↑	.07025 .03220	.03727 .02069 N.S.	.06967 .02259 N.S.	.08432 .00754	.08559 .00725 N.S.	.10292 .00668 ↑
3.	HAZARDOUS MANUEVERS	.03075 .00480	.02795 .00439 N.S.	.02389 .00347 ↓	.00826 .01141	.01553 .01350 N.S.	.00410 .00567	.02970 .00461	.02725 .00422 N.S.	.02268 .00327 ↓
4.	1 + 2	.04381 .00569	.03665 .00501 N.S.	.08805 .00643 ↑	.06612 .03131	.03106 .01895 N.S.	.07582 .02349 N.S.	.04484 .00562	.03633 .00485 ↓	.08730 .00621 ↑
5.	2 + 3	.00904 .00263	.00944 .00258	.00993 .00225	.00413 .00808	.00621 .00858	.00615 .00694	.00882 .00254	.00926 .00248	.00970 .00216
6.	1 + 3	.01949 .00384	.01203 .00291 ↓	.01718 .00295 N.S.	.03719 .02384	.00621 .00858	.03074 .01531 N.S.	.02031 .00383	.01170 .00279 ↓	.01801 .00293 N.S.
7.	1 + 2 + 3	.00703 .00232	.00426 .00174	.01181 .00245 ↑	.00826 .01141	.00621 .00858	.00615 .00694	.00709 .00228	.00437 .00171	.01146 .00234 ↑
8.	NORMAL	.64590 .01329	.68499 .01239 ↑	.53879 .01132 ↓	.48347 .06296	.53727 .05446 N.S.	.40574 .04357 ↓	.63837 .01304	.67568 .01212 ↑	.53061 .01098 ↓
9.	DBL LANE CHANGES	.01467 .00334	.01777 .00352 N.S.	.01678 .00292 N.S.	.00826 .01141	.00621 .00858	.00410 .00567	.01437 .00323	.01712 .00336 N.S.	.01600 .00276 N.S.

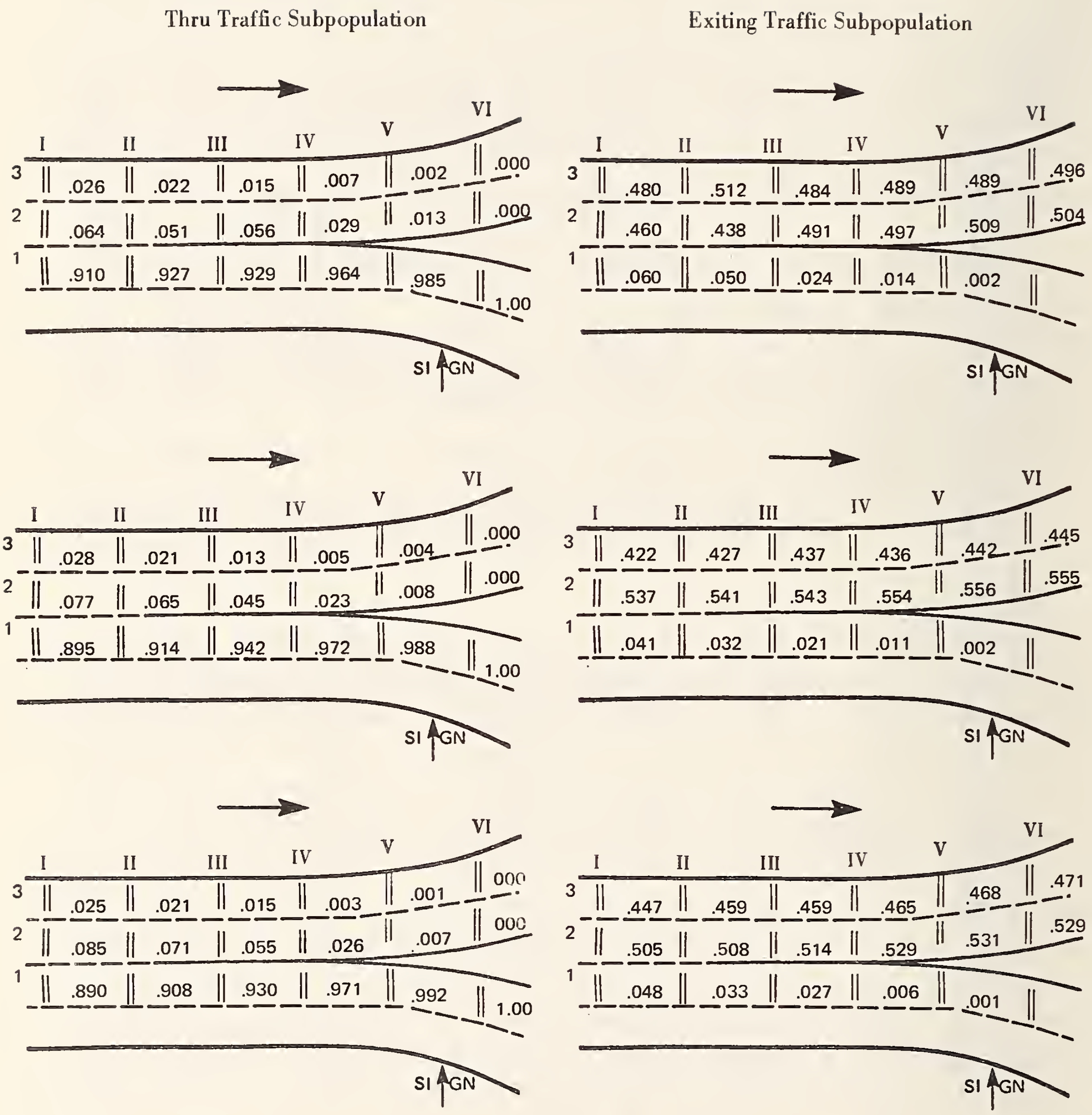


Figure 57. Proportional location of traffic during nonrush period at Interchange 17 North for three observation days in the Acclimation phase.

Interchange 16 South. More extensive coverage was given to this interchange. Data were taken during rush and nonrush periods at both the advance sign (G-2) and at the gore (G) on the day before, the two days immediately after sign change and three weeks later on the day of the week matching the first day after sign change.

At the G-2 sign during the rush period, one hypothesis would predict that change in the signing would lead to a greater frequency of lane changing in the form of both preparatory and through maneuvers. This was not confirmed. The TES findings suggest rather that subsequent to the sign modifications, there was a general smoothing effect on traffic flow which was sustained throughout the after period of observation. Specifically, the proportion of normal traffic (i.e., within the appropriate speed envelope, adequate following distance and no hazardous maneuvers) was about 41 percent on the day before and was 49 percent, 44 percent and 46 percent in the three days of data collection following the change in signs. All the after phase proportions are significantly higher than the before proportions by statistical test. The frequency of preparatory maneuvers at the G-2 location during rush-hour actually *declined* on the first two after days (from 92 per thousand to 67 and 75 per thousand, respectively). By the end of three weeks, however, the decline was no longer discriminable by statistical test (circa 83 per thousand).

In the nonrush period (about 1800 vehicles per hour in three lanes as opposed to about 3500 vehicles in three lanes during the rush period), part of the hypothesized effect did occur but there was a trend toward a general stabilization effect as well. During nonrush, the proportion of preparatory maneuvers (i.e., into the right-most lane) did not change. The proportion of leftward movements out of that lane (through maneuvers) did increase by a statistically significant amount which was sustained during the after observation period. The quantities were circa 89 per thousand before and 106, 106 and 118, respectively in the after phase. It should be noted that a similar increase in through maneuvers at the advance location was found in the main Before/After study.

Similarly, the proportion of normal traffic was 55 percent before and 58 percent, 55 percent and 57 percent in the successive observations made after the change. While the differences are small in an absolute sense, the increase on the first day after and that observed three weeks after the sign change, are statistically significant.

At the gore, it was not possible for mechanical reasons to obtain TES records during the rush period on the day before the signs were changed. Consequently, no before/after comparisons can be made for this time period. However, it may be suggestive that in the after phase, there was a progressive increase in the proportion of normal traffic from about 51 percent to 55 percent on the second day and to 57 percent at the end of three weeks. Each successive difference is statistically significant.

For the nonrush hour period at the gore of Interchange 16 South, the traffic volume entering the array was approximately 1700 vehicles per hour of which some 400+, or circa 25 percent, exit. (It should be noted that three of the four through traffic lanes were instrumented.)

The general summary tables showing the proportions of vehicles making hazardous maneuvers, headway violations, etc. showed few significant differences. The level of normal traffic, for example, was about 53 percent before and stayed about this level (i.e., 52 percent and 51 percent, respectively) on the two days immediately following the change. Three weeks later, the level was about 59 percent which is statistically significant but should probably be interpreted cautiously even though the statistics are consistent in showing significant reductions in speed anomolies and speed anomolies plus hazardous maneuvers on that day. One reason for caution would be that headway violations and hazardous maneuvers (alone) actually increased.

Figure 58 shows the placement of exiting and through vehicles by the proportion of each subpopulation traversing each tapeswitch trap. For exiting vehicles, it will be noted in the exit ramp (i.e., Lane 1) at Trap 5, the proportion fluctuates around .98; but after three weeks it is down to .966, suggesting poorer performance. (It is a significant decline by statistical test.) In terms of entry position at Trap 1, exiting traffic shows no consistent improvement after the change in signs. For through traffic, the same effect noted in the main Before/After study is seen. Fewer through vehicles enter the array in Lane 1 and fewer exit the array in this lane. The declines are significant for the two days following sign change at both Traps 1 and 6 but are not significant three weeks later.

In summary, few significant changes were found with the TES immediately after the change in signs at 16 South. During the nonrush period at the G-2 location, the main finding was a significant increase in through maneuvers which was maintained throughout each after observation period. A similar finding emerged in the main Before/After study.

At the first gore, few differences were found. However, lane placement data did show a significant shift of through vehicles out of Lane 1 (the lane which is dropped at the second gore of this interchange) on the two days immediately following sign change. The same trend was apparent three weeks later but did not reach the .05 level of significance. The same shift for through vehicles was noted in the main Before/After study. No benefit was found in lane placement data for exiting traffic.

Exiting Subpopulation

Thru Subpopulation

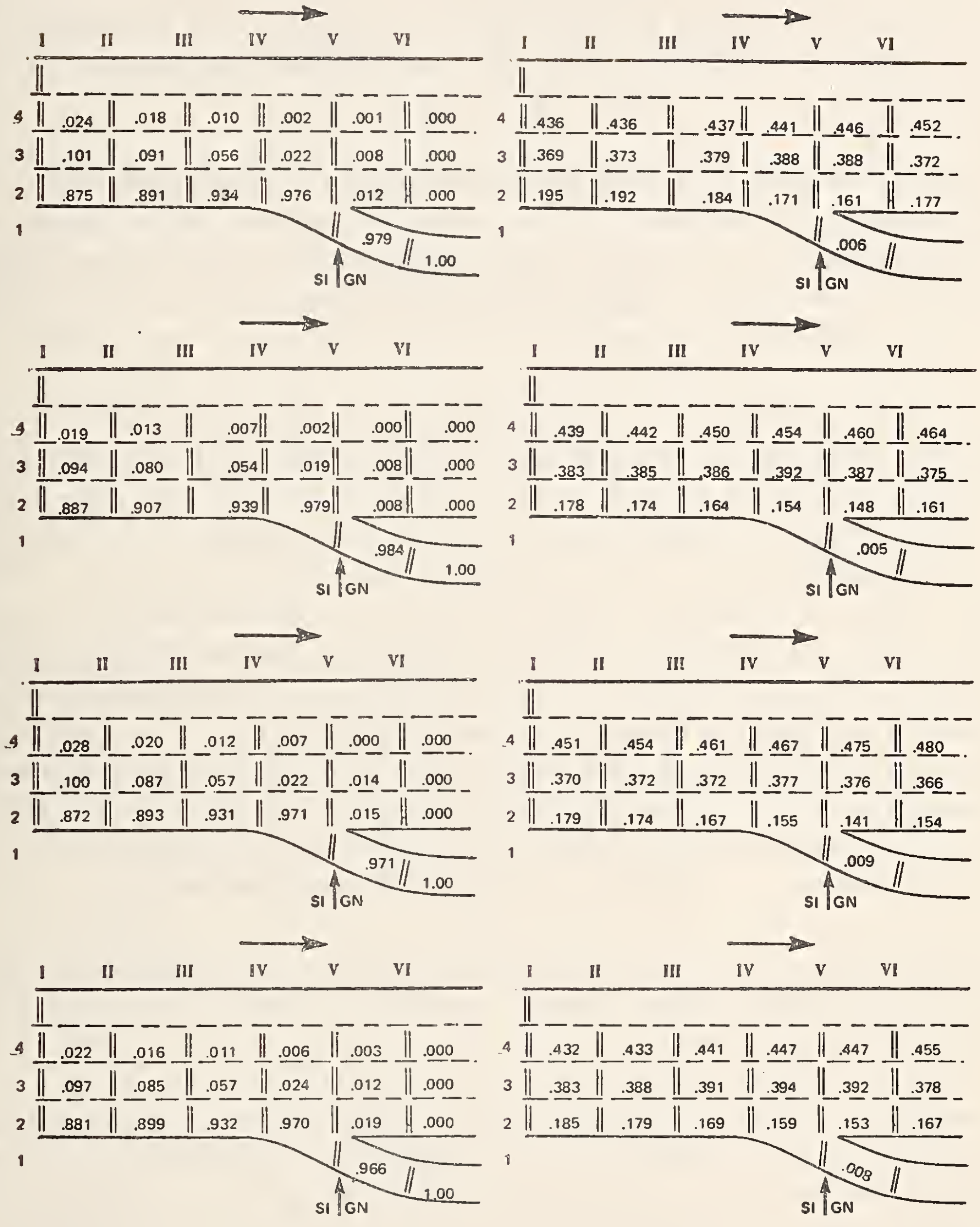


Figure 58. Proportional location of traffic during nonrush period at Interchange 16 South for four successive periods in the Acclimation phase.

Motorist Questionnaire/Interviews

Tables on the following pages provide the frequency and percentage of motorists selecting each response category for each question. Questionnaire items have been divided into categories: sample characteristics, trip characteristics, items related to signing, additional comments and exit characteristics. Results are described below in each category. Relationships between license plate and route familiarity are then described. Discussion and summary paragraphs conclude this section.

Sample Characteristics. In general, the characteristics of the respondent samples on the days before and after signing change at the two interchanges were similar. One of the most noticeable differences is in distribution of ages at Interchange 16 South where, on the day before the signs were changed, a high proportion (41 percent) of the sample were 20 to 30 years old. This age group constituted about 25 percent of the other samples.

Other examples of before/after sample differences are in occupation and in the state in which the vehicle license plate was issued. Concerning occupation, the business-related category is relatively low (56 percent versus 70 percent) and the student and unemployed categories relatively high (19 percent versus four percent) in the sample obtained at 16 South after the signs were changed compared to the proportions in these categories on the day before the signs were changed. Concerning vehicular license plates, the after sample of 16 South contained more respondents (80 percent) with Maryland plates than did the before sample (63 percent for the samples collected at 17 North). This sample also contained the lowest percentage of respondents who might be classified as unfamiliar with the area on the basis of license plate (two percent). (It will be recalled that on the basis of license plate, vehicles with U.S. Government, District of Columbia, Maryland and Virginia plates were classified as local drivers.) With the exception of the 16 South after sample, about ten percent of the samples carried plates other than local and thus presumedly had unfamiliar drivers.

Comparing samples across the interchanges, the most noticeable difference is that at 17 North. Sixty to 70 percent of the motorists questioned were men while at 16 South the sexes were about equally represented.

To summarize, the general characteristics of the samples of motorists drawn on the day before and the days after signing change were similar. The typical respondent was slightly more likely to be a man than a woman, aged between 20 and over 50, employed and not serving in the military. With high probability, the respondent resided within 30 miles of the District of Columbia and most likely his license plate was issued by the State of Maryland. He had occupied his present residence more than two years and drove more than 15,000 miles per year.

Questionnaire Tabulation – Acclimation Phase

	17 North				16 South			
	Before (N = 37)		After (N = 95)		Before (N = 27)		After (N = 86)	
Sample Characteristics	f	%	f	%	f	%	f	%
Sex								
Male	22	59.5	66	69.5	13	48.1	45	52.3
Female	15	40.5	29	30.5	14	51.9	41	47.7
No answer	0	0	0	0	0	0	0	0
Age								
Less than 20 years	1	2.7	3	3.2	0	0	4	4.7
20 – 30 years	10	27.0	23	24.2	11	40.7	22	25.6
31 – 40 years	13	35.1	25	26.3	5	18.5	17	19.8
41 – 50 years	8	21.6	25	26.3	5	18.5	21	24.4
Over 50 years	5	13.5	19	20.0	5	18.5	17	19.8
No answer	0	0	0	0	1	3.7	5	5.8
Occupation								
Business	26	70.3	63	66.3	19	70.4	48	55.8
Housewife	10	27.0	17	17.9	6	22.2	19	22.1
Student	0	0	6	6.3	0	0	9	10.5
Unemployed	1	2.7	2	2.1	1	3.7	7	8.1
Military	0	0	5	5.3	0	0	0	0
No answer	0	0	2	2.1	1	3.7	3	3.5
Residence								
Local – within 30 miles and not/unknown military	32	86.5	80	84.2	24	88.9	73	84.9
Local – within 30 miles and military	0	0	0	0	0	0	0	0
More than 30 miles and not/unknown military	1	2.7	4	4.2	0	0	6	7.0
More than 30 miles and military	0	0	1	1.1	0	0	0	0
Md., Va., D.C. – distance unknown & not/unknown military	0	0	1	1.1	0	0	0	0
Md., Va., D.C. – distance unknown and military	0	0	0	0	0	0	0	0
States other than Md., Va., D.C. and not/unknown military	4	10.8	5	5.3	2	7.4	2	2.3
States other than Md., Va., D.C. and military	0	0	2	2.1	0	0	0	0
No answer or incomplete answer	0	0	2	2.1	1	3.7	5	5.8
Period of Residence								
Less than 1 month	1	2.7	3	3.2	0	0	0	0
1 month to 6 months	4	10.8	4	4.2	2	7.4	3	3.5
7 months to 1 year	4	10.8	9	9.5	2	7.4	5	5.8
More than 1 year to 2 years	3	8.1	9	9.5	2	7.4	4	4.7
More than 2 years	25	67.6	64	67.4	20	74.1	70	81.4
No answer	0	0	6	6.3	1	3.7	4	4.7

Questionnaire Tabulation – Acclimation Phase

	17 North				16 South			
	Before (N = 37)		After (N = 95)		Before (N = 27)		After (N = 86)	
Sample Characteristics (Continued)	f	%	f	%	f	%	f	%
Miles Driven Per Year								
Less than 5,000	4	10.8	6	6.3	1	3.7	5	5.8
5,000 – 10,000	9	24.3	15	15.8	7	25.9	19	22.1
10,000 – 15,000	11	29.7	27	28.4	7	25.9	20	23.3
More than 15,000	13	35.1	46	48.4	11	40.7	39	45.3
No answer	0	0	1	1.1	1	3.7	3	3.5
State in Which License Issued								
Government; no State	0	0	3	3.2	1	3.7	0	0
District of Columbia	4	10.8	3	3.2	3	11.1	9	10.5
Virginia	7	18.9	19	20.0	3	11.1	6	7.0
Maryland	22	59.5	58	61.1	17	63.0	69	80.2
Other Eastern States	4	10.8	9	9.5	3	11.1	2	2.3
Central States	0	0	2	2.1	0	0	0	0
Mountain States	0	0	0	0	0	0	0	0
Pacific States including Alaska & Hawaii	0	0	1	1.1	0	0	0	0
Foreign	0	0	0	0	0	0	0	0
No answer	0	0	0	0	0	0	0	0
Trip Characteristics								
Reason Traveling Today								
Business; related to occupation	19	51.4	50	52.6	15	55.6	35	40.7
Vacation or recreation	6	16.2	3	3.2	4	14.8	8	9.3
Shopping	4	10.8	13	13.7	4	14.8	20	23.3
Taking children somewhere	1	2.7	1	1.1	0	0	3	3.5
Appointment – not business/children	1	2.7	1	1.1	2	7.4	3	3.5
Other (visit, going to school)	5	13.5	24	25.3	1	3.7	16	18.6
No answer	1	2.7	3	3.2	1	3.7	1	1.2
Trip Origin								
Within 30 miles of D.C.	33	89.2	86	90.5	23	85.2	77	89.5
30 to 100 miles from D.C.	3	8.1	2	2.1	1	3.7	8	9.3
More than 100 miles from D.C.	1	2.7	6	6.3	2	7.4	1	1.2
No answer	0	0	1	1.1	1	3.7	0	0
Trip Destination								
D.C. area or within 30 miles	32	86.5	80	84.2	27	100.0	86	100.0
30 to 100 miles from D.C.	1	2.7	4	4.2	0	0	0	0
More than 100 miles from D.C.	4	10.8	9	9.5	0	0	0	0
No answer	0	0	2	2.1	0	0	0	0
Map Use								
Using map on trip	2	5.4	7	7.4	0	0	4	4.7
Not using map on trip	35	94.6	88	92.6	27	100.0	82	95.3
No answer	0	0	0	0	0	0	0	0

Trip Characteristics. In terms of trip characteristics, samples of motorists drawn on the day before and the days after signing change were also similar. The most frequently cited reason for traveling was business (about 50 percent). About 90 percent of the trips had originated within 30 miles of the District of Columbia and the great majority were terminating in the same area. Map use was infrequent (seven percent or less, depending on the sample). Seat belts were in use by 37 percent or less of the samples and shoulder belts by 11 percent or less.

The most frequently cited reason for route selection was that the route was faster (about 75 percent for each sample). More than 90 percent of each sample had driven the route before and 76 percent to 85 percent of each sample had driven it more than 20 times before. At least 82 percent had driven it within the last 30 days.

There are few before/after sample differences. The most notable is the decrease in business as the reason for traveling in the after sample at 16 South (56 percent of the before sample versus 41 percent for the after sample) with accompanying changes in alternate reasons for traveling, particularly increases in shoppers and the "Other" (visit, etc.) category.

There are also few differences in trip characteristics across the two interchanges. Most notable is that the trip destination for *all* respondents at 16 South was within 30 miles of the D.C. area as compared to about 85 percent for the 17 North samples.

Signing. Few motorists reported trouble with the signs under either the conventional or diagrammatic signing condition. However, the proportion reporting trouble was higher under the conventional signing condition at both interchanges eight percent versus two percent at 17 North and 11 percent versus two percent at 16 South). These ten cases were reviewed in detail. Despite the reports of difficulty with the signing, all but one had driven the route before, and all but three had driven it over 20 times and within the last 30 days. Only two carried license plates from states other than Maryland, Virginia or the District of Columbia. Trip origins and destinations for all but one were local (within 30 miles of the District of Columbia). This is not unexpected, however, because almost the entire sample of 245 motorists had driven the route before (only two had not) and most more than 20 times (see Trip Characteristics, previously discussed).

The causes cited by those few reporting difficulty with the signs are shown. The numbers are too small to compare the various reasons given under the two conditions of signing. However, it might be noted that over all categories of reasons, considerably fewer reasons for the difficulty are given by respondents under the diagrammatic signing condition.

Questionnaire Tabulation – Acclimation Phase

	17 North				16 South			
	Before (N = 37)		After (N = 95)		Before (N = 27)		After (N = 86)	
Trip Characterisitcs (Continued)	f	%	f	%	f	%	f	%
Seat Belts								
In use	10	27.0	24	25.3	10	37.0	26	30.2
Not in use	27	73.0	66	69.5	17	63.0	53	61.6
Car not equipped with seat belts	0	0	3	3.2	0	0	5	5.8
Not observed	0	0	2	2.1	0	0	2	2.3
Shoulder Belts								
In use	1	2.7	6	6.3	3	11.1	7	8.1
Not in use	22	59.5	67	70.5	14	51.9	53	61.6
Car not equipped with shoulder belts	13	35.1	22	23.2	10	37.0	25	29.1
Not observed	1	2.7	0	0	0	0	1	1.2
Reason for Selecting Route[1]								
Shorter	15	40.5	27	28.4	8	29.6	36	41.9
Faster	28	75.7	75	78.9	21	77.8	65	75.6
Scenic areas	0	0	2	2.1	0	0	2	2.3
Less traffic	0	0	4	4.2	1	3.7	4	4.7
Most likely not to get lost	0	0	5	5.3	3	11.1	2	2.3
No particular reason	0	0	2	2.1	0	0	2	2.3
Other	3	8.1	6	6.3	1	3.7	3	3.5
Four or more answers	0	0	0	0	0	0	0	0
No answer	0	0	0	0	0	0	1	1.2
Route Familiarity								
Driven Route Before?								
Yes	35	94.6	89	93.7	27	100.0	84	97.7
No	2	5.4	3	3.2	0	0	2	2.3
No answer	0	0	3	3.2	0	0	0	0
Number Times Driven Route Before								
Five times or less	1	2.7	7	7.4	0	0	8	9.3
6 – 10	3	8.1	7	7.4	2	7.4	2	2.3
11 – 20	1	2.7	3	3.2	2	7.4	3	3.5
Over 20	29	78.4	72	75.8	23	85.2	69	80.2
No answer	3	8.1	6	6.3	0	0	4	4.7
Driven Route Within Past 30 Days?								
Yes	32	86.5	78	82.1	23	85.2	73	84.9
No	3	8.1	10	10.5	3	11.1	8	9.3
No answer	2	5.4	7	7.4	1	3.7	5	5.8
Signing								
Trouble With Signs?								
Yes	3	8.1	2	2.1	3	11.1	2	2.3
No	34	91.9	93	97.9	24	88.9	84	97.7
No answer	0	0	0	0	0	0	0	0

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[1] Some respondents gave more than one answer. Therefore, the summed percentage selecting each answer exceeds 100%. "No answer" directly reflects percentage of sample which did not select one or more answers.

Questionnaire Tabulation – Acclimation Phase

	17 North				16 South			
	Before (N = 37)		After (N = 95)		Before (N = 27)		After (N = 86)	
Signing (Continued)	f	%	f	%	f	%	f	%
Cause of Sign Trouble[1]								
Signs did not contain proper information	2	5.4	1	1.1	3	11.1	1	1.2
Not enough signs	1	2.7	1	1.1	0	0	0	0
Too many signs in one place	1	2.7	0	0	0	0	0	0
Signs poorly placed	3	8.1	0	0	0	0	0	0
Signs hard to understand	1	2.7	2	2.1	2	7.4	0	0
Other	1	2.7	0	0	1	3.7	1	1.2
Five or more answers	0	0	0	0	0	0	0	0
No answer	34	91.9	93	97.9	24	88.9	84	97.7
Sign Did Not Contain Proper Information; Information Sought Was[1]								
Name of city, town or destination	2	5.4	0	0	1	3.7	0	0
Road name	2	5.4	0	0	0	0	0	0
Route number	0	0	1	1.1	2	7.4	1	1.2
Cardinal direction (e.g., North)	0	0	0	0	1	3.7	0	0
Exit number	1	2.7	0	0	0	0	0	0
Other	1	2.7	0	0	0	0	0	0
Four or more answers	0	0	1	1.1	0	0	0	0
No answer	34	91.9	93	97.9	25	92.6	85	98.8
Information Which Would Have Been Most Useful on Interstate Signs Just Seen[1]								
Name of city, town or destination	31	83.8	67	70.5	13	48.1	51	59.3
Road name	7	18.9	27	28.4	13	48.1	36	41.9
Route number	18	48.6	47	49.5	10	37.0	26	30.2
Cardinal direction (e.g., North)	8	21.6	25	26.3	5	18.5	16	18.6
Exit number	6	16.2	14	14.7	2	7.4	10	11.6
Other	1	2.7	3	3.2	1	3.7	2	2.3
Four or more answers	0	0	3	3.2	0	0	1	1.2
No answer	1	2.7	0	0	2	7.4	9	10.5
Diagrammatic Signing								
Have You Seen Signs Like These Before?								
Yes	–	–	65	68.4	–	–	50	58.1
No	–	–	29	30.5	–	–	35	40.7
No answer	–	–	1	1.1	–	–	1	1.2
If Seen Before, How Often?								
Once or twice	–	–	9	9.5	–	–	10	11.6
A few times	–	–	28	29.5	–	–	26	30.2
Many times	–	–	27	28.4	–	–	14	16.3
No answer	–	–	31	32.6	–	–	36	41.9

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[1] Some respondents gave more than one answer. Therefore, the summed percentage selecting each answer exceeds 100%. "No answer" directly reflects percentage of sample which did not select one or more answers.

Questionnaire Tabulation – Acclimation Phase

	17 North				16 South			
	Before (N = 37)		After (N = 95)		Before (N = 27)		After (N = 86)	
Diagrammatic Signing (Continued)	f	%	f	%	f	%	f	%
If Seen Before, Where?								
Va., Md., D.C. – specific location	–		12	12.6	–		12	14.0
Va., Md., D.C. – no specific location	–		11	11.6	–		2	2.3
Elsewhere – specific location	–		0	0	–		6	7.0
Elsewhere – no specific location	–		11	11.6	–		12	14.0
Foreign countries	–		2	2.1	–		0	0
Doubtful accuracy	–		12	12.6	–		3	3.5
Both U.S. & foreign locations	–		3	3.2	–		2	2.3
Don't remember	–		9	9.5	–		6	7.0
No answer	–		35	36.8	–		43	50.0
What do You Think of These Signs?								
Favorable, nonspecific	–		114	82.6	–		91	92.9
Unfavorable, nonspecific	–		5	3.6	–		5	5.1
Favorable, 17N	–		11	8.0	–		0	0
Unfavorable, 17N	–		4	2.9	–		0	0
Favorable, Democracy Blvd.	–		0	0	–		0	0
Unfavorable, Democracy Blvd.	–		4	2.9	–		0	0
Favorable 16S	–		0	0	–		1	1.0
Unfavorable 16S	–		0	0	–		1	1.0
Total Comments			138				98	
Respondents who did not comment			1	1.05	–		2	2.3
Additional Comments								
Favorable comments on Beltway/I-70S	6	28.6	14	40.0	4	20.0	17	32.7
Unfavorable comments on Beltway/I-70S	15	71.4	21	60.0	16	80.0	35	67.3
Total comments	21	100.0	35	100.0	20	100.0	52	100.0
Respondents who did not comment	20	54.1	63	66.3	13	48.1	44	51.2
Respondents expressing dissatisfaction with sign message	3	8.1	2	2.1	3	11.1	2	2.3
Exiting Characteristics								
Reason for exiting								
Exit on way to destination	36	97.3	92	96.8	27	100.0	85	98.8
To turn around	1	2.7	0	0	0	0	1	1.2
To get further information	0	0	0	0	0	0	0	0
Two or more answers	0	0	0	0	0	0	0	0
No answer	0	0	3	3.2	0	0	0	0
Was Exit Correct?								
Yes	36	97.3	95	100.0	27	100.0	85	98.8
No	1	2.7	0	0	0	0	1	1.2
Unknown but lost	0	0	0	0	0	0	0	0

All respondents were asked to indicate the information which would have been most useful to them on the signs they had just passed. There is little difference in the distribution of responses for the samples collected before and after the change in signs at either interchange and no changes that are consistent across interchanges. It is interesting to note that the proportion of respondents requesting destination information both before and after signing change at 17 North is about double that at 16 South. Signs at both interchanges included destination information.

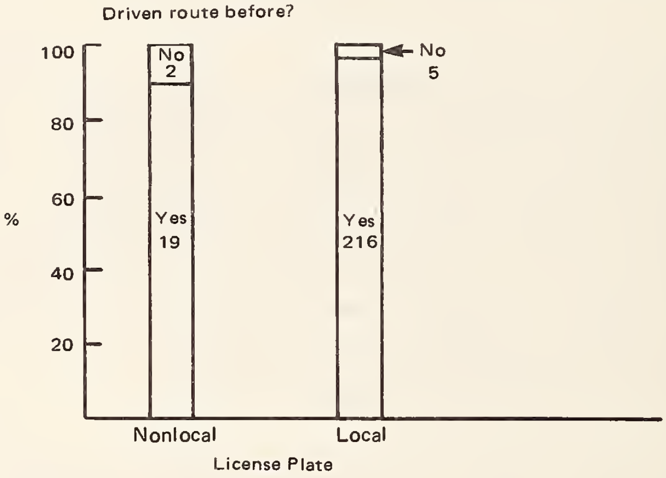
Those respondents who were sampled after the signs were changed to diagrammatics were asked whether they had seen signs like these before and their opinion of them. As shown in the table, more than half the respondents at both interchanges indicated that they had seen diagrammatics before and 16 percent (16 South) to 28 percent (17 North) said that they had seen them many times before. These motorists indicated a variety of locations as the place where they had seen such signs. The great majority (83 percent at 17 North, 93 percent at 16 South) commented favorably on the signs. Most comments were nonspecific although a few were specifically directed at particular interchanges as shown.

Additional Comments. In an open-ended question, motorists were asked if they had other comments about the signing on the Beltway/I-70S. One-third to one-half of each sample responded to this question. A few used this question as an opportunity to comment on aspects other than signing (e.g., highway geometry) but most responded to the request for signing comments.

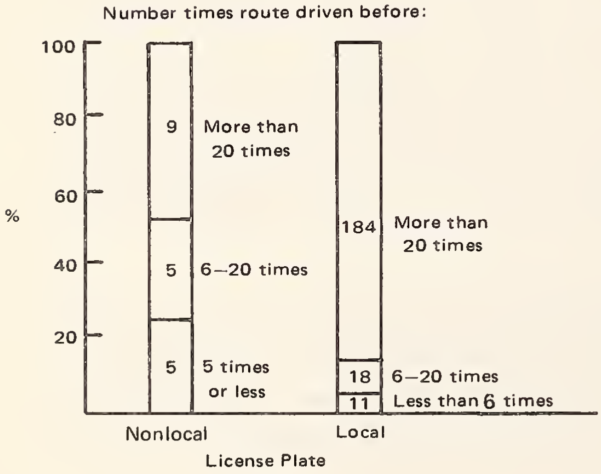
The table shows the proportion of the total comments received that were favorable or unfavorable before and after signing change. At both interchanges, the proportion of favorable comments increased and the proportion of unfavorable comments decreased after the signs were changed to diagrammatics. A Chi-square test (using Yates' correction) of these data, collapsed across the two interchanges, does not reach the .05 level of significance, however ($X^2 = 1.14$, df = 1). The table also shows that there was a decrease in the number of respondents who expressed dissatisfaction with the sign message after the signs were changed to diagrammatics (eight percent versus two percent at 17 North, 11 percent versus two percent at 16 South).

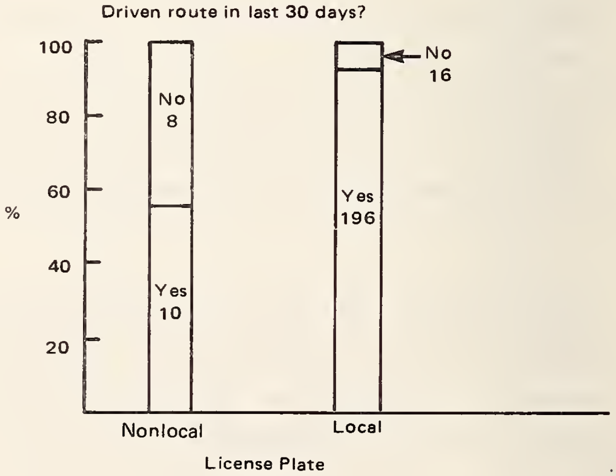
Exiting Characteristics. Almost all motorists gave as their reason for exiting that the exit was on the way to their destination. Only two of the entire population of motorists were exiting in order to turn around. These are the same two motorists who are shown in the table as respondents who were exiting incorrectly. Both of these motorists also reported difficulty with the signs.

License Plate and Route Familiarity. Because license plate is used as an index of route familiarity with the Traffic Evaluator System (TES), the validity of this index as established by motorist interviews is of considerable interest. It will be remembered that manual code inputs to the TES separated vehicles into local (those with Maryland, Virginia, District of Columbia, or Government plates) and nonlocal classes (those with all other plates).



The figure partitions motorists with local or nonlocal plates by their response to the question of whether they had driven the same route before. For those who had driven it before, the next two figures show the number of times the route was driven before and whether it had been driven within the past 30 days.





It will first be noted that nonlocal plates were found on only 21 of the total sample of 242 or 9 percent of the vehicles. Of these nonlocal vehicles, 90 percent had driven the route before as compared to 98 percent of the local vehicles. A Chi-square test, using Yates' correction, shows that this relationship between local versus nonlocal license plates and having driven the route before is not significant ($X^2 = 1.48$, df = 1, $p > .05$, one-tailed test).

The second bar graph depicts the frequency of times that respondents stated they had driven the route before and whether their license plate was categorized as local or nonlocal. Twenty-six percent of those with nonlocal plates had driven the route five times or less before whereas only five percent of those with local plates had driven the route five times or less before. Forty-seven percent of those with nonlocal plates had driven the route more than 20 times whereas 86 percent of those with local plates had driven it more than 20 times. A Chi-square test of this relation is significant at the .001 level ($X^2 = 20.15$, df = 2, one-tailed test).

The last bar graph indicates that 56 percent of those with nonlocal plates had driven the route within the past 30 days whereas 92 percent of those with local plates had driven it within the same period. Using Yates' correction, a Chi-square test of these data is significant at the .001 level ($X^2 = 20.38$, df = 1, one-tailed test). The contingency coefficient, C, is .29 for this value of Chi-square. Because the maximum C value for a 2 x 2 table is 0.5, a coefficient of 0.29 represents 0.58 of a "perfect" or one-to-one relationship between local versus nonlocal license plates and having driven or not having driven the route within the last 30 days.

Discussion. In the Acclimation phase study, as in the Before/After study, demand sampling was used which can be assumed to approximate a random sample of exiting vehicles. In both the Acclimation phase and the Before/After studies the samples contained a great majority of vehicles with local plates. Even those vehicles with nonlocal plates generally contained drivers who had at least some familiarity with the route. While significant relationships between having driven the route a number of times before or having driven it within the last 30 days and possession of a local license plate were found, the relationships were far less than perfect. Similar findings were made in the main Before/After study.

As regards the particular issues of interest in the Acclimation phase study, a primary objective was to assess whether the new signs had an impact on local traffic. A secondary objective was to evaluate the effect of the signs on drivers unfamiliar with the area.

The questionnaire data are not illuminating with regard to the secondary objective because the number of drivers unfamiliar with the area was so small. With regard to the first objective, it was clear that the local motorists did notice the new signs and that their response to them was favorable. Their comments were enthusiastically made. The motorists did not suggest that they had been so interested in the signs that they had paid little attention to the road and thus missed turns, narrowly avoided accidents or experienced other detrimental consequences.

Summary. The great majority of motorists interviewed resided locally and were familiar with the route. The new signs were viewed favorably by the respondents. Fewer respondents reported difficulty with the signs after they were changed but the numbers were too small to test significance. Indirect measures, such as the proportion of general comments that were favorable or unfavorable before and after signing change, also suggested that the new signs were viewed favorably by motorists. Although significant relationships were demonstrated between local/nonlocal license plates and frequency of driving the route before or whether the route had been driven within the last 30 days, these relationships were less than perfect. Fifty-six percent of those with nonlocal plates had driven the route within the past 30 days; 74 percent had driven it six times or more. For local plates, the equivalent percentages were 92 percent and 95 percent. These figures may be considered as upper bounds, however, since only exiting vehicles could be interviewed. Exiting vehicles would more likely contain drivers residing locally than would the through traffic stream.

Acclimation Phase Conclusions

It was speculated at the outset of the Acclimation study that several alternative consequences could emerge from a dramatic change in guide sign characteristics. First, it seemed possible that there would be an acute disruption in the behavior of drivers due in part to the surprise aspect of the change and in part to a perceptual distraction generated by the actual information contained on the sign. The acute disruption could be expected to dissipate rapidly leading to a return of the numerical values of the indicators to a baseline condition. A second alternative was that there would be no effects detectable. A third alternative was that some facilitation of driver performance would occur immediately and be sustained. The fourth alternative was that facilitation effects, if found, would quickly dissipate.

In fact, a combination of these alternatives seemed to occur. Drivers interviewed indicated that they had definitely noticed the new signs, particularly those at 16 South. They also liked them. Some confusion did occur, however. For example, there was some difficulty relating the message to the graphic. A comment at 16 South was that the driver expected the first exit to be listed first. Though this is the obvious procedure on a conventional sign, on a graphic for a two-exit interchange, the second exit will appear at the top of the sign opposite the downstream arrow.

There is some indication that the new signs in the advance and exit direction locations generate earlier preparation for exit and through behavior at the gore with consequently fewer hazardous maneuvers in the gore area. The small benefits observed in the gore area were mainly for through traffic at both interchanges studied. Evidence for major negative effects immediately after the change in signs was certainly not found.

Most drivers, however, are probably so familiar with the routes that they use onto, along and off of I-495 that they do not rely on signing in any way. Even drivers of the so-called "foreign" vehicles turned out to be highly familiar with I-495 and its idiosyncracies. The number of drivers who are actually strangers in the sense of no prior experience turned out to be surprisingly small. If over 90 percent of drivers are completely nondependent on signs, then it is easy to see why changing the signs would have a barely discernable effect.

In brief, those effects that were detectable were, on balance, favorable for diagrammatic as opposed to conventional signs. Some of the favorable effects were transient; others seemed to be stable once achieved. Much of the impact appears to be lost against the background made up of a very large majority of drivers who function on the particular roadway in question without recourse to the information displayed on highway guide signs.

CHAPTER VII

ERROR SOURCES AND THE TRAFFIC EVALUATOR SYSTEM

Many of the results presented in Chapter VI were developed from data collected with the Traffic Evaluator System. Whether these results present a valid picture of motorist response to the two types of signing requires answers to two questions:

- Did the Traffic Evaluator System itself significantly affect motorist behavior?
- What degree of error is associated with the use of the Traffic Evaluator System?

This Chapter is concerned with these two questions.

Impact Of The Traffic Evaluator System On Traffic Behavior

Introduction

A recurrent problem in scientific research is evaluating whether a measurement device changes behavior of the system being measured. This question is of particular interest in using the Traffic Evaluator System. While the cameras are small and can easily be located in inconspicuous locations, the Traffic Evaluator System involves tapeswitches across the highway, a recorder, power supplies, and, on some days, human observers coding the vehicles by license and vehicle type. Every effort was made to reduce the conspicuity of the system. The recorder and power supplies were placed in concealed locations, and the human observers wore dark clothing and stationed themselves so that they were difficult to detect by passing traffic. The tapeswitches, however, could not be completely disguised. The gray tape used to attach them to the highway was the closest match that could be obtained, but it was not perfect. In addition to the possibility of visual detection, there are also some noise and vibration associated with passage over them.

Three types of investigations were performed to evaluate the effect of the TES on traffic behavior. In these investigations, lane usage, lane changing behavior and vehicular speed were measured when the tapeswitches were deployed and when they were absent from the same section of roadway.

Lane Usage And Lane Changing Behavior

In these evaluations, time-lapse films were used. Films were made one week prior to and on a day when the Traffic Evaluator System was in use. From the paired films, the volume of traffic using each lane and the number and type of lane changes in the presence and absence of the TES were compared.

The most likely location where such changes might be detected is at those sites with one or more lanes not instrumented with tapeswitches. Such sites provide vehicles with the option of moving into the uninstrumented lane to avoid the tapeswitches. Because the number of tapeswitches which could be included in the array was limited, uninstrumented lanes occurred where the road was four lanes wide or where it was three lanes wide with an accompanying deceleration lane. Specifically, the sites with uninstrumented lanes were the three sites at 17 North (G–2, G–1, and the gore) and the gore sites at 16 South, 18 East, and 18 West.

Attention is first turned to 17 North where the most detailed analysis of the pre-evaluator and with-evaluator films was undertaken. At this interchange, Lane 1, the most right-hand lane of traffic, was not instrumented. Both the G–2 and G–1 sites were studied the same week, so motorists passed through two successive arrays of switches, each array extending over 1500 feet, within about one mile of highway. The gore area was instrumented on another week. Two different types of switches were used. The G–2 and G–1 sites were instrumented with model RB, while the gore area was instrumented with model 131. The model RB is a heavy-duty switch which is more detectable to motorists visually or through noise/vibration or both. From these facts, it would be expected that if a disruption of traffic is associated with the Traffic Evaluator System, it would most likely be found at the G–1 site where the motorist would have passed the most switches and where the switches were of the more detectable model. Three questions were asked:

- Does the proportion of traffic using Lane 1 (uninstrumented) increase when the Traffic Evaluator System is deployed?
- Is the number of vehicles entering or leaving Lane 1 affected by the Traffic Evaluator System?
- Is the distribution of traffic movements of particular interest in this study affected by the Traffic Evaluator System?

Concerning the last question, "movements of particular interest" at the gore are erratic maneuvers (i.e., movements across the painted gore or its extension line) as well as other lane changes (those not involving the painted gore or its extension line). At the G–2 and

G–1 signs, they are similar movements, but because the gore extension line does not exist at these sites, they are movements across the theoretical projection of that line which would separate Lanes 2 and 3.

The results of this analysis are shown in Figures 59 through 61. The figure legends correspond to each of the three questions above.

Figure 59 shows the number of vehicles using Lane 1, 2, 3, and 4 at each site with and without the Traffic Evaluator System. A Chi-square test of these data was significant at only one site, the gore. It will be remembered, however, that the most likely site for significant results was the G–1 site. In addition, review of the 17 North gore table in Figure 59 reveals that the deviations from expected values lead to contradictory interpretations. The volume of traffic using the uninstrumented lane exceeded the expected values, but so too did the volume of traffic using Lanes 3 and 4 which were instrumented.

Further information is found in Figure 60 where single lane changes into and from the uninstrumented lane in the presence and absence of the Traffic Evaluator System were investigated. None of the Chi-square values approach significance.

Finally, Figure 61 deals with the question of whether the distribution of movements of particular interest in the study varied with the presence or absence of the Traffic System. The only significant Chi-square value was the G–1 site. This is not the same site as that where the only other significant Chi-square was found.

Attention is next turned to the other three sites where there were uninstrumented lanes; 16 South, 18 East, and 18 West. The model 131 tapeswitch was used to instrument 16 South. The more detectable RB model was used at the other two sites. The only question asked here was whether the single vehicle lane changes into or out of the adjacent uninstrumented lane were significantly different with or without the Traffic Evaluator System in use. As shown in Figure 62, no significant differences were found.

When the above data are reviewed *in toto*, it is concluded that there is no firm evidence that the Traffic Evaluator System affects lane usage or lane changing behavior. Certainly, the Traffic Evaluator System does not cause gross and consistent changes in traffic behavior as measured by lane usage or lane changes. Attention is now turned to an evaluation of the influence of the tapeswitches on vehicular speed.

17 North G–2

	I–70S Lanes 3 & 4	I–495	
		Lane 2	Lane 1
Pre-Eval	2231 (2222.54)	1090 (1119.76)	750 (728.69)
With Eval	2219 (2227.46)	1152 (1122.24)	709 (730.31)

$X^2 = 2.8894$
df = 2
$.30 > p > .20$

17 North G–1

	I–70S Lanes 3 & 4	I–495	
		Lane 2	Lane 1
Pre-Eval	2080 (2073.47)	1228 (1249.12)	946 (931.41)
With Eval	2123 (2129.53)	1304 (1282.88)	942 (956.59)

$X^2 = 1.1964$
df = 2
$.70 > p > .50$

17 North G

	I–70S Lanes 3 & 4	I–495	
		Lane 2	Lane 1
Pre-Eval	2258 (2318.86)	1322 (1247.25)	1063 (1076.89)
With Eval	2574 (2513.14)	1277 (1351.75)	1181 (1167.11)

$X^2 = 12.0291$
df = 2
$.01 > p > .001$

Figure 59. Does the proportion of traffic in Lane 1 (uninstrumented) increase when the Traffic Evaluator System is deployed?

17 North G–2

	Single Lane Changes	
	Into Lane 1	From Lane 1
Pre- Eval	34 (36.01)	31 (28.99)
With Eval	43 (40.99)	31 (33.01)

$X^2 = 0.4726$
df = 1
$.50 > p > .30$

17 North G–1

	Single Lane Changes	
	Into Lane 1	From Lane 1
Pre- Eval	179 (177.02)	39 (40.98)
With Eval	145 (146.98)	36 (34.02)

$X^2 = 0.2597$
df = 1
$.70 > p > .50$

17 North G

	Painted Gore		Gore Extension Line	
	Single Lane Changes		Single Lane Changes	
	Into Lane 1	From Lane 1	Into Lane 1	From Lane 1
Pre- Eval	48 (49.28)	32 (30.74)	54 (55.63)	28 (26.35)
With Eval	53 (51.72)	31 (32.26)	60 (58.37)	26 (27.65)

$X^2 = 0.4607$
df = 3
$.95 > p > .90$

Figure 60. Is the number of vehicles entering and leaving Lane 1 (uninstrumented) affected by the Traffic Evaluator System?

17 North G–2

	Over Extension Line[1]		Other Lane Change
	Move Left	Move Right	
Pre-Eval	70 (69.11)	65 (65.65)	141 (141.24)
With Eval	90 (90.89)	87 (86.35)	186 (185.76)

$X^2 = 0.0322$
df = 2
$.98 > p > .95$

17 North G–1

	Over Extension Line[1]		Other Lane Change
	Move Left	Move Right	
Pre-Eval	52 (58.57)	180 (195.07)	314 (292.35)
With Eval	63 (56.43)	203 (187.93)	260 (281.65)

$X^2 = 6.6292$
df = 2
$.05 > p > .02$

17 North G

	Over Painted Gore		Other Lane Change	Over Extension Line		Other Lane Change
	Move Left	Move Right		Move Left	Move Right	
Pre-Eval	44 (39.01)	70 (66.66)	129 (126.41)	38 (41.97)	65 (67.16)	131 (135.79)
With Eval	35 (39.99)	65 (68.34)	127 (129.59)	47 (43.03)	71 (68.84)	144 (139.21)

$X^2 = 2.9094$
df = 5
$.80 > p > .70$

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[1] "Over extension line" indicates the theoretical projection of the painted gore extension line to the G-2 and G-1 sites.

Figure 61. Is the distribution of traffic movements affected when the Traffic Evaluator System is deployed?

16 South

	Single Lane Changes	
	Into Instr. Lane	From Instr. Lane
Pre-Eval	82 (81.83)	56 (56.17)
With Eval	87 (87.17)	60 (59.83)

$X^2 = 0.0017$
df = 1
$.99 > p > .98$

18 East

	Single Lane Changes	
	Into Instr. Lane	From Instr. Lane
Pre-Eval	31 (29.74)	28 (29.26)
With Eval	31 (32.26)	33 (31.74)

$X^2 = 0.2051$
df = 1
$.70 > p > .50$

18 West

	Single Lane Changes	
	Into Instr. Lane	From Instr. Lane
Pre-Eval	80 (73.89)	34 (40.11)
With Eval	60 (66.11)	42 (35.89)

$X^2 = 3.0414$
df = 1
$.10 > p > .05$

Figure 62. Is the number of vehicles entering and leaving the uninstrumented lane affected by the Traffic Evaluator System?

Vehicular Speed[1]

In an attempt to determine whether or not the presence of Traffic Evaluator System tapeswitches deployed on a roadway have an effect on motorists' driving speed, a study was made using radar speed measurements. The procedure consisted of making simultaneous speed readings on instrumented and non-instrumented segments of roadway to ascertain what speed changes existed when tapeswitches were deployed. Then a similar comparison of vehicular speeds was made at the same two locations on a day when the switches were not deployed.

The four cell matrix shown in Figure 63, which is descriptive of the study design, permits a comparison of normative driving speeds not influenced by the presence of tapeswitches as well as speed changes which may be attributable to the presence of tapeswitches.

	Non-instrumented Mode	Instrumented Mode
Point 1	Normal Speed	Normal Speed
Point 2	Speed With No Switches	Speed With Switches

Figure 63. Speed observation matrix.

The site used for the speed comparison study was the eastbound approach to Exit 18 on the Capital Beltway (see Figure 64). The site possessed no extreme geometric characteristics (sight distance, grade) which would confound a speed study.

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[1] Fred Hanscom conducted this study and prepared the results. His contribution is gratefully acknowledged.

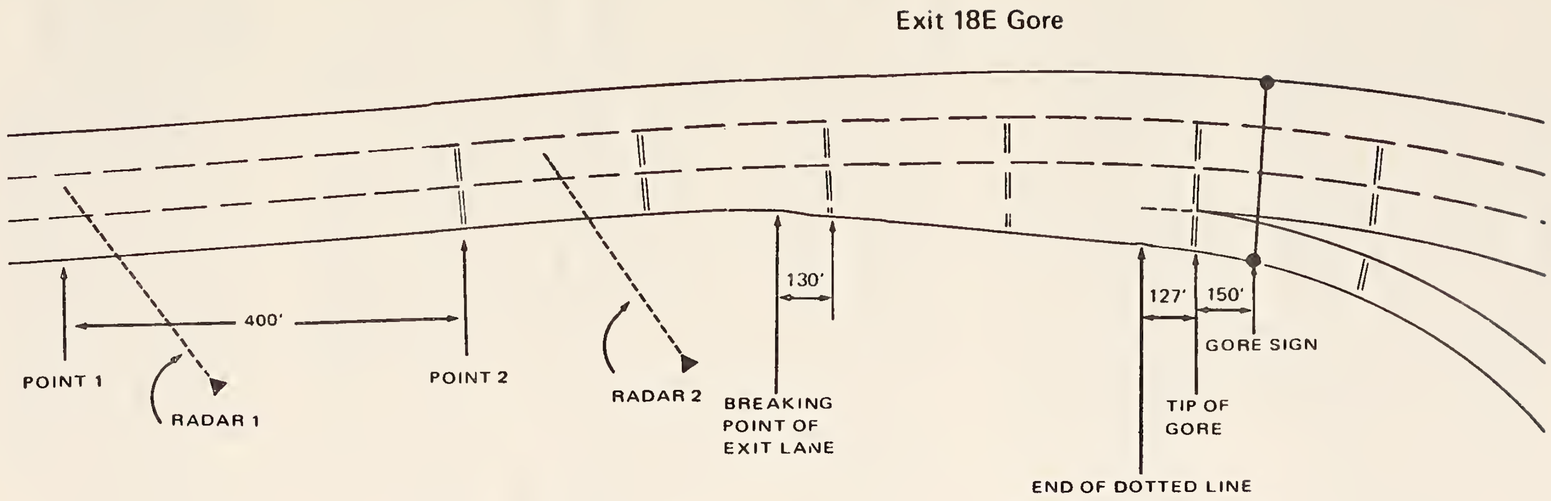


Figure 64. Locations of radar units used for speed comparisons.

Point 1 (as indicated in Figure 64) was located 400 feet upstream from the first trap in a six trap array of tapeswitches deployed to evaluate motorist behavior for the diagrammatic signing study. The tapeswitches were not visible from Point 1, and speeds at that location were felt to be indicative of normal driving for the study area. Point 2 was selected approximately midway between the first two switch pairs in the array. Driver behavior at this point was susceptible to the influence of the presence of tapeswitches, yet interaction with vehicles making exiting maneuvers was not a factor. The tapeswitches deployed were the more noticeable RB model.

Two identical Decatur radar meters were used to take speed measurements. To minimize the effects of any peculiarities between the radar units, the same meter was used for all measurements at Point 1; and likewise the other unit was used at Point 2. Hence, any differences were accounted for in the "between locations" comparisons.

Speed changes were recorded between locations only for non-exiting vehicles traveling in the center lane in order to wash out all possible confounding influences on the motorist. By utilizing walkie-talkie communications between Points 1 and 2, it was possible to record speeds in a matched-pair format describing behavior of individual vehicles rather than by mere random sampling at each point.

To eliminate variable conditions imposed by time, day and season, a before/after analysis was made by observations between the hours of 1000 and 1500 on two successive Thursdays in September. The first day of observation was the data collection period for the instrumented situation, and the following week data were collected for the non-instrumented condition. Observers and radar units were located so as to minimize their visibility to motorists.

The analysis was based on samples consisting of 390 matched pairs of speed readings for each condition. The analysis yielded mean speeds and standard deviations as shown in each cell of the matrix in Figure 65. Correlation coefficients between speeds at Points 1 and 2 were calculated and are shown with the matrix.

The higher mean speeds shown for the non-instrumented mode may be due to the operation of the radar meters on different days. As a rule, the accuracy of radar readings is reliable only to about 2 mph. It is also possible that actual vehicle speeds were higher on that particular day. In either event, the higher relative speeds at Point 2 compared to Point 1 are believed to be reliable as the radars were synchronized prior to data collection.

Observed speeds: mph

	Non-instrumented Mode	Instrumented Mode
Point 1	$\bar{X}$ = 56.44 σ_x = 3.94	$\bar{X}$ = 53.10 σ_x = 3.84
Point 2	$\bar{y}$ = 58.36 σ_y = 3.98	$\bar{y}$ = 54.21 * σ_y = 4.62
	r_{xy} = .76	r_{xy} = .66

(* = cell in which switches were deployed)

Figure 65. Speed matrix with observed values for mean speeds and standard deviations.

Although the difference of mean values between all cells is relatively small (less than one standard deviation), all means are significantly different by the t test. An examination of the relative values for t's indicated that a much greater difference was found between conditions (differences caused by presence of tapeswitches) than between points (differences caused by site characteristics). It will be noted that there is a higher coefficient of correlation in the non-instrumented case.

An analysis of speed changes between Points 1 and 2 for the instrumented and the non-instrumented cases is summarized in Figure 66. A test between the means of speed changes between Points 1 and 2 reveals significance. The lesser speed change in the instrumented case implies that fewer motorist increased their speed (in compliance with the normative trend) between Points 1 and 2 because of the presence of tapeswitches.

Average Speed Changes

Non-instrumented Mode	+1.92 mph σ = 2.59
Instrumented Mode	+1.11 mph σ = 3.51

Figure 66. Observed averages and standard deviations of speed differences of vehicles between Points 1 and 2.

Conclusions

From films collected one week prior to and on the day when the Traffic Evaluator System was in use, no firm evidence that the TES affects lane usage or lane changing behavior was found. A radar speed comparison between instrumented and non-instrumented segments of roadway showed slight differences in speed when the tapeswitches were present compared to when they were absent from the road. Passage over the tapeswitches was associated with a small but significant reduction in speed. The mean difference was less than one mile per hour, however. Although this difference applies to the absolute values of mean speed provided in Chapter VI, it is not considered to significantly affect the main results of the Before/After or Acclimation phase studies. In these studies, the proportion of vehicles meeting a 5 mph speed difference criterion were compared with tapeswitches employed in *both* conditions.

Levels Of Error Associated With The Traffic Evaluator System

Introduction

In research which concentrates on human behavior, many forms of measurement error can enter into the process. In the present instance, the object of investigation can be defined as driver behavior approaching selected interstate interchanges and the type of measurement as principally the detection of specified events—i.e., categorical behavior based on the track taken by the driver through the interchange area. Two instruments were used to obtain observations of this type; the principal instrument was the Traffic Evaluator System and the back-up instrument was time-lapse photography.

As described in detail in Chapter III, the Traffic Evaluator System is essentially an electromechanical device. Switch closures constitute the operation by which the raw data is assembled. The major component of the raw data is generated by switch closures instigated by the passage of a motor vehicle over a tapeswitch on the roadway. However, some of the raw data comes from switch closures instigated by human observers via manual code boxes. Such systems have intrinsic sources of error. For example, the tapeswitches are susceptable to various mechanical and electrical failures. The physical stresses on the device in the field are severe. Malfunctions can lead to detection failures. Fortunately, most malfunctions are such that signal transmission terminates and the presence of the malfunction is obvious. However, some intermittent failures do occur which become, in effect, false readings.

The manual input to the Traffic Evaluator System is susceptible to operator error which is inherent in repetitive monitoring or "vigilance" tasks (Bergum & Klein, 1961).

Finally, the Traffic Evaluator System is susceptible in its mechanical detector component to extrinsic sources of error in the sense that events occur which exceed the logical bounds of the device. For example, the buffer storage units can become overloaded in heavy traffic conditions or in light traffic conditions if the chance distribution of vehicles is such that a number of switches are closed nearly simultaneously. These occurrences cause loss of data. Another example is a vehicle following another in the same lane which makes a very quick passing maneuver and returns to the original lane just ahead of the vehicle it was originally following. The software contains constraints limiting permissible variation in vehicle characteristics, but if the wheelbases and speeds of the two are similar at the next trap, the software may be incapable of tracking the two vehicles accurately. Such instances lead to loss of data or erroneous data.

With respect to time-lapse photography, the basic principles are the same. The camera itself has certain inherent limitations related to its fixed field of view and monocular perspective. Extrinsic factors involve the chance obscuration of one vehicle by another by interposition. Human errors intrude since the film is scored by human operators under conditions which are conducive to loss-of-vigilance effects.

The basic question in all this is whether the errors are extensive enough to distort the research findings. Several investigations were undertaken to determine the magnitude of error arising from various sources.

Level of Error Evaluations

Six types of analysis were undertaken to develop a picture of the error levels associated with data collection. One involved an internal check on the Traffic Evaluator System. Four involved cross-comparisons between the TES and data derived from matched time-lapse films. Finally, the variability among manual coders was evaluated.

Internal check. The internal check for the Traffic Evaluator System (TES) was limited to TES measurement of wheelbase or interaxle distance in the vehicles crossing a switch-pair. The measurement is based on the time between front axle and rear axle contact for a given switch and vehicle velocity. Velocity is established from the difference between the time a given axle contacts the first switch in the pair and the time the same axle contacts the second switch in the pair. It can be seen that the accuracy of the computation of velocity and also of wheelbase is a function of the precision of switch placement and the pulse-timing capability of the system. If there were errors in speed measurement, these would be compounded and amplified in the wheelbase calculation. Since there were six switch pair closures for each complete vehicle track through the array, each track provides a sample of six estimates of wheelbase. The error computation was made by subtracting the lowest estimate from the highest estimate and dividing that difference by the average estimate for the vehicle track.

The average error in wheelbase estimation for an unbiased sample of 50 vehicles was 4.1 percent.

Cross comparisons between the TES and data derived from matched time-lapse films. Four types of comparisons were made as follows:

- axle counts
- vehicle counts
- lane change counts
- identification of individual vehicles.

Failure of the Traffic Evaluator System to track all axles will occur when (1) tapeswitches and/or the recorder are inoperative, and/or (2) traffic volume is sufficiently heavy that the memory capacity of the recorder is overloaded. Even if all axles are recorded, there is another source of error. This is the accuracy of translation of axles into vehicles.

An estimation of error was made by comparing the number of axles recorded at each trap in the tapeswitch array between 1100 and 1130 on 18 May at the 16 South G–2 site, converting to vehicles using certain assumptions about vehicle type, and comparing these data to the number of vehicles recorded on film during the same time period.

Axle count errors were aggregated for all lanes covered for each of six traps (i.e., there was a data-point based on circa 1000 vehicles for each trap location). Error scores ranged from a minimum of 0.1 percent at Trap 3 to 3.2 percent at Trap 6. Average error for the full array was 1.8 percent.

Vehicle counts, as such, were derived from a special ten-minute segment of matched Traffic Evaluator System output and a time-lapse film sequence obtained on September 22, 1971 at the 17 North G–1 site. Vehicle counts were made for each lane separately at the last two switch pairs (Trap 5 and Trap 6) which were nearest to the camera. This provided six semi-independent check points (three instrumented lanes and two trap locations).

The degree of error ranged from zero at Trap 6 in Lane 3 to 5.0 percent at Trap 5 in Lane 1. The average error for the six data-points was 2.8 percent.

An estimate of reliability was made using the interclass correlation measure as specified by Guilford (1954). In this test, r_{11} was found to be 0.988, which is the more conservative estimate of the reliability of the instruments individually. When together, the combined instruments would have a reliability of 0.994.

In this comparison, the TES data produce consistently lower scores than the film reveals. That is, the error is all in one direction. This is because the software edit routine rejects vehicle tracks that fail to meet established standards.

Lane change counts were made from the same matched sample in the same locations (i.e., lane changes among the three lanes covered by the Traffic Evaluator System between switch pairs 4 and 5 and between pairs 5 and 6). Lane change counts between Traps 4 and 5 were identical between the Traffic Evaluator System and time-lapse photography (i.e., 15). Between Traps 5 and 6, the Traffic Evaluator System detected 13 lane changes but only 12 could be discerned in the photographic record. Pooling these figures, an average error of about five percent is obtained. It should be noted, however, that this discrepancy may well be a case of vehicle interposition on the film record. That is, in this particular measure, the errors are again unidirectional with any discrepancy more probably due to a detection failure in film scoring than a detection failure in the TES.

Again, using the matched ten-minute sequence taken on September 22, 1971, an attempt was made to cross-identify every vehicle in the two records. The objective was to find the route history of each vehicle present on the photographic record in the TES record. In other words, a vehicle-to-vehicle correspondence check was done for about 50 vehicles in the set. (Circa 300 vehicles were in the ten-minute sample.)

The results of this effort were perhaps the most impressive of the matched comparisons made. We were particularly interested in the extreme ends of the TES record because of possible anchoring ambiguities. Therefore, about 30 vehicles at the beginning of the record (circa one minute of sequence) and about 20 vehicles at the end of the record were tracked in detail. Matching vehicles in the film with the output of the TES proved quite feasible though tedious. The relative gaps between vehicles across the three instrumented lanes and the lane changing behavior of the vehicles as they traversed the tapeswitch array as shown by the film were mirrored faithfully in the software output. Only one vehicle recorded by the Traffic Evaluator System was not susceptible to positive identification via the photographic record and this was a vehicle that was approaching Trap 5 at the onset of the recording sequence (i.e., the vehicle crossed only two switch pairs during the observation period).

Manual Coding. A manual coding accuracy check was done using four operators over five test intervals on September 20, 1972 at the G–1 location for Interchange 17 North. Each coder assigned vehicles to one of the eight categories using the eight pushbutton manual keyboard and the coding strategy described in Chapter IV. For purposes of this test, all coders coded the same lane. Using the aggregate counts for each coder on each test as the raw score, the average reliability figure for a *single* coder (based on the Guilford method of interclass correlation) was .989.

Conclusions

While any system combining optical, mechanical, electrical, electronic, and manual components is susceptible to a variety of errors, the quality control checks indicate that these errors are nominal under normal conditions. The system as a whole contains sufficient internal checks so that a failure of the sort that would lead to erroneous findings would be apparent in the ordinary inspection procedures that accompany data reduction.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

A field study of traffic behavior and motorist preference was conducted comparing conventional and diagrammatic signing on seven approaches to five interchanges. Before (conventional signing) and After (diagrammatic signing) data collection periods were separated by one year. One of the approaches was used as a control. Signs on this approach were not changed to diagrammatics but remained conventional throughout the study.

A smaller study, the Acclimation phase, was undertaken between the Before and After studies at the time the signs were changed. This investigation was conducted on two of the approaches included in the main Before/After study. Baseline data were collected the day before the signs were changed and on the two days immediately following sign change. Follow-up data collection continued up to six weeks later.

Three methods were used in the Before/After and Acclimation phase studies. These were the Traffic Evaluator System, time-lapse photography and motorist response to a questionnaire.

The Traffic Evaluator System is a recently developed device which permits collection of a great variety of vehicle characteristics including absolute and relative speed, space headway, time headway, tailway, wheelbase and axle number at a number of points on a section of roadway instrumented with tapeswitches. The TES represents a considerable advance over previous instruments in that these data are collected on all vehicles passing through the array and that data collected at successive tapeswitch trap locations can be integrated with data collected earlier. As a result, vehicles can be tracked as they pass through the array permitting study of vehicle interaction and lane changing behavior.

Because the TES was first used on this project, several experiments were undertaken to evaluate its accuracy and to determine whether the instrument itself (particularly the tapeswitches used on the roadway) caused major changes in traffic behavior. Comparison of time-lapse films and TES data collected simultaneously showed that the TES provides an accurate picture of traffic behavior. From films made at the same location in the presence and absence of the Traffic Evaluator System, no consistent significant differences in lane usage or lane changing behavior were found. Radar speed measurements comparing instrumented and uninstrumented segments of roadway in the presence and absence of the tapeswitches showed a small (ca. 1 mph) but significant reduction in speed when vehicles entered the tapeswitch array. Because the tapeswitches were present in both diagrammatic and conventional signing evaluations, this effect is controlled and does not affect comparisons made in the study.

Several types of performance measures were used to compare traffic behavior under the conventional and diagrammatic signing conditions. These were lane changing behavior, lane placement, headway violations (headways of one second or less) and the proportion of vehicles traveling at least 5 mph less than the mean speed (speed difference).

Lane changing behavior, particularly erratic maneuvers, has traditionally been used in signing research. Evidence that erratic maneuvers are related to driver interchange negotiation difficulty was collected in the course of this study. A significant relation was found between performance of such maneuvers and driver statement of difficulty. The relationship was not perfect, however.

By lane placement is meant the position of particular subpopulations of vehicles as they enter and exit the tapeswitch array. No validation of this measure is known. However, it is clearly related to erratic maneuvers.

The headway violation measure has not been validated. It has a logical basis in that driving is a time-sharing task. If more attention is devoted to studying signs (because they are more confusing, have a higher information content, etc.), less attention can be devoted to maintaining vehicle control and short headways may result.

The speed difference measure has been related to accident likelihood by Cirillo (1968) and Solomon (1966).

The above measures were the best that could be found and/or developed for the purposes of this study, given the time constraints under which it was done. The development of validated measures for evaluation of candidate guide signs is an area requiring considerable further research.

Results of the main Before/After study are summarized in the table on the following pages. In brief, traffic behavior at the control interchange was essentially unchanged by the passage of one year. For the single right exit interchanges (15 North, 16 North, and 18 East), results were either no change (15 North and 16 North) or some benefit for some subpopulations of vehicles at the gore (18 East). The last could not be traced back to changes at the advance and/or exit direction locations, however. It is concluded that at these locations, diagrammatic signs had little effect.

At the cloverleaf, Democracy Boulevard, small improvements were found at the first gore in terms of hazardous maneuvers and lane placement for both exiting and through traffic. An increase in preparatory maneuvers was found at the advance sign, which might be expected in light of the reduction in hazardous maneuvers for exiting traffic. The situation at this interchange is extremely complex, however, because of residual effects from the upstream interchange, 17 North, which will be discussed later. No effect was found at the second gore.

Data at the complex interchange, 16 South, are mixed. There are two successive right exits at this interchange with a lane drop at the second. A small but significant reduction in through traffic usage of the lane which will be dropped was found in the vicinity of the first and second gores. This was accompanied by an increase in through maneuvers at the advance sign. However, because of the increase in headway violations and hazardous maneuvers in the vicinity of the first gore, it must be concluded that clear evidence favoring one or the other type of sign was not found at this interchange.

At the gore of Interchange 17 North, a clear benefit from diagrammatic signs was found. This is a left exit major fork in which the left two of four lanes exit as I-70S; the right two continuing as I-495. Approximately half the traffic exits.

With the exception of headway violations on which results were mixed, all measures showed significant reductions after the signs were changed. As a consequence, the proportion of vehicles meeting none of the criteria of speed difference, headway violations and/or hazardous maneuvers increased.

The reduction in hazardous maneuvers (which are counted for both through and exiting traffic as movements across the gore or its painted extension line) was particularly dramatic. Before phase values were two to three times greater than After phase values (e.g., ten percent compared to four percent for nonautos on one of the paired data collection days). Reductions in the proportions of vehicles meeting the speed difference criterion were also sizable (the reduction was in the order of six percent to eight percent for the population as a whole and for most subpopulations). Both through and exiting vehicle populations were benefitted.

INTER-CHANGE	SIGN & EXIT CHARACTERISTICS	METHOD	RESULTS	COMMENT
15 North	Gore Single right exit; no deceleration lane	Time-lapse films	No significant change in hazardous maneuvers.	Approach does not include advance or exit direction signs; A single sign at the gore is provided.
16 North	Gore Single right tangential off ramp; no deceleration lane	Time-lapse films	No significant change in hazardous maneuvers.	
	Exit Direction.	Time-lapse films	No significant change in preparatory or through maneuvers.	
	Advance	Time-lapse films	No significant change in preparatory or through maneuvers.	
16 South	First Gore Right off ramp onto a collector-distributor; no deceleration lane	TES	Speed differences significantly reduced but hazardous maneuvers and headway violations increased. No significant difference in lane placement for exiting traffic. Significantly smaller proportions of through vehicles using the lane which will be dropped at the second gore	
	Second Gore Lane drop	Time-lapse films	Significant reduction in lane changing. Significantly fewer lane changes of exiting vehicles. Movements of through traffic from the lane which will be dropped are significantly reduced.	
	Exit Direction	Time-lapse films	No significant difference in preparatory, through, or other lane changing maneuvers.	
	Advance	Time-lapse films	Significant increase in through maneuvers. Reduced usage of the lane which will be dropped by through traffic at the gore may be attributable to this increase in through maneuvers at the advance sign.	Note that at 17 North, the significant improvement at the gore could also be traced back to the advance sign.

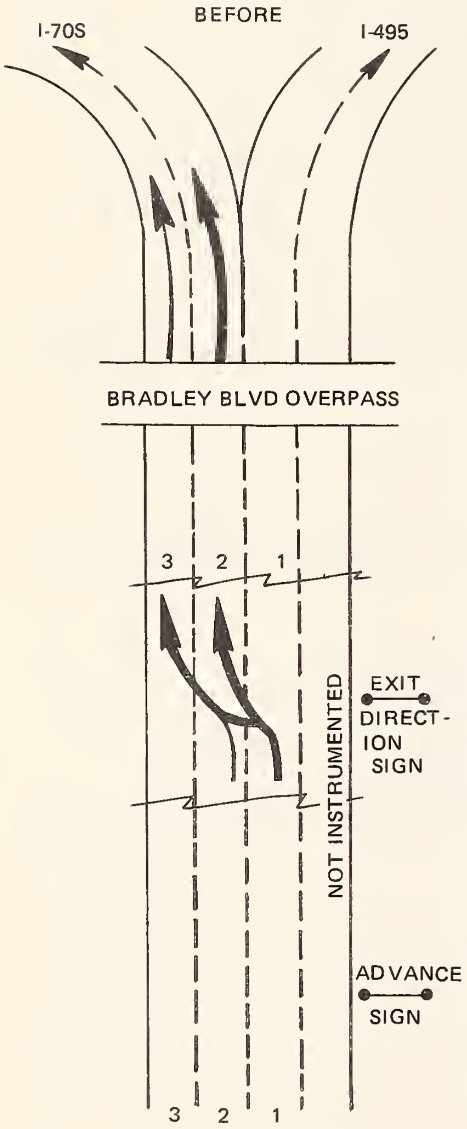
INTER-CHANGE	SIGN & EXIT CHARACTERISTICS	METHOD	RESULTS	COMMENT
17 North	Gore Major fork; left two lanes exit as I-70S, right 2 lanes continue as I-495.	TES	With the exception of headway violations on which results are mixed, other measures show a clear improvement. Hazardous maneuvers reduced by a factor of two or three depending upon population. Speed differences reduced. Lane placement indicates a significant benefit.	A special study of Labor Day traffic was conducted in the Before and After phases using time-lapse films of the gore and exit direction locations. Results confirmed main Before/After study. Benefit for through traffic equals or exceeds that for exiting traffic.
	Exit Direction	TES	Significant reduction in vehicular maneuvering; particularly preparatory maneuvers and other lane changes. Significant shift in patterns of movements to the left and right through the tapeswitch array.	
	Advance	TES	Significant increase in through maneuvers. Preparatory maneuvers also increased; significantly for one pair of matched days. The data suggest that changes in traffic behavior at the gore and shifts in movement patterns at the exit direction location can be traced back to changes at the first sign in the array, the advance sign.	The diagrammatic advance sign depicted a left exit major fork. No information of an upcoming left exit was provided by the conventional sign at this location.
Democracy Blvd.	First Gore Right exit to partial cloverleaf	TES	Significant reduction in hazardous maneuvers and an improvement in lane placement for through and exiting traffic. Differences are small, however.	Conclusion based on one pair of Before/After days.
	Second Gore Right exit to partial cloverleaf.	Time-lapse films	No effect of diagrammatics on erratic maneuvers.	Incidence of erratic maneuvers too small for the measure to be meaningful.
	Exit Direction	Time-lapse films	Preparatory and through maneuvers unchanged in the diagrammatic condition.	

INTER-CHANGE	SIGN & EXIT CHARACTERISTICS	METHOD	RESULTS	COMMENT
	Advance	Time-lapse films	Preparatory maneuvers significantly increased. No significant change in through maneuvers.	Sign at this location unchanged. Increase in preparatory maneuvers may be attributable to residual effects of the change in traffic behavior at 17 North under the diagrammatic signs.
18 East	Gore Single right exit with deceleration lane	TES	Significant reductions in hazardous maneuvers especially for nonauto and nonlocal subpopulations. Lane placement data showed exiting traffic entered deceleration lane and exit ramp more promptly. For through traffic, the incidence of entries into the deceleration lane was reduced. No consistent significant differences in other measures (e.g., speed differences).	
	Exit Direction	TES	Significant increase in through maneuvers for some populations. Preparatory maneuvers unchanged Significant reduction in proportion of vehicles traveling at low speeds. Slight but significant increase in headway violations.	At the gore, exiting traffic and nonauto and nonlocal subpopulations showed most benefit. These changes cannot be traced back to equivalent changes at the exit direction sign.
	Advance	TES	No significant changes in lane changing maneuvers or lane placement. Proportion of vehicles meeting speed difference criterion decreased but this was somewhat offset by an increase in headway violations.	Changes at the gore cannot be traced back to changes at the advance sign.
18 West	Gore Single right exit with deceleration lane	TES	No consistent significant differences in speed differences, headway violations, hazardous maneuvers or combinations of these; nor in the proportion of vehicles classified as normal. Lane usage by exiting and through vehicles was also unchanged.	This was the control interchange. Signs were not changed and remained conventional in the Before and After phases.

INTER-CHANGE	SIGN & EXIT CHARACTERISTICS	METHOD	RESULTS	COMMENT
	Exit Direction	TES	Significant reduction in preparatory and through maneuvers and in double lane changes; significant increase in vehicles performing no lane changes. Speed differences and headway violations unchanged. Lane placement data indicates patterns of movement did not change.	The reduction in preparatory and through maneuvers was not reflected in changes in traffic behavior at the gore. Conclusion based on one pair of matched days.
	Advance	TES	No significant differences in vehicular maneuvers. For other criteria, the only change was a reduction in speed differences which resulted in an increase in vehicles classified as normal. Lane placement data indicate patterns of movement unchanged in After phase.	Conclusion based on one pair of matched days.

Changes at the gore were accompanied by changes at the advance sign location, noticeably a significant *increase* in through maneuvers. Significant *reductions* in vehicular maneuvers were found at the exit direction location. Lane placement data, however, showed a significant change in maneuver patterns at the exit direction sign location. The change suggested that in the After phase, movements at the exit direction sign were continuations of movements begun upstream.

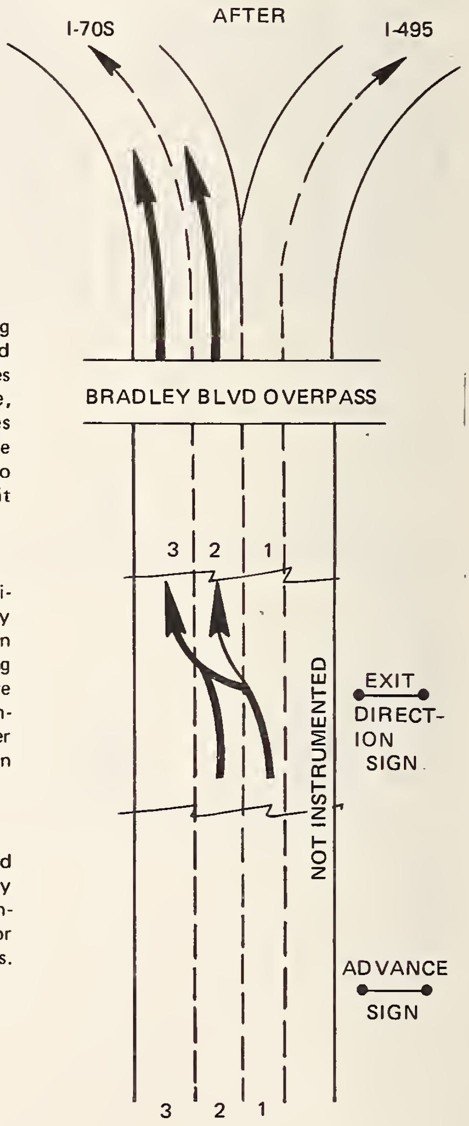
Lane placement data in combination with maneuvers of various types at three signing locations are illustrated below for exiting traffic.



In the After phase, exiting traffic is evenly distributed across the two exit lanes whereas in the Before phase, a larger proportion of vehicles are found in Lane 2. These differences can be traced to congruent changes at the exit direction and advance signs.

Vehicle maneuvering significantly reduced, particularly preparatory maneuvers. Shift in pattern of leftward moving vehicles. These are more evenly distributed on entry into the array in the After phase and a larger proportion exit the array in Lane 3.

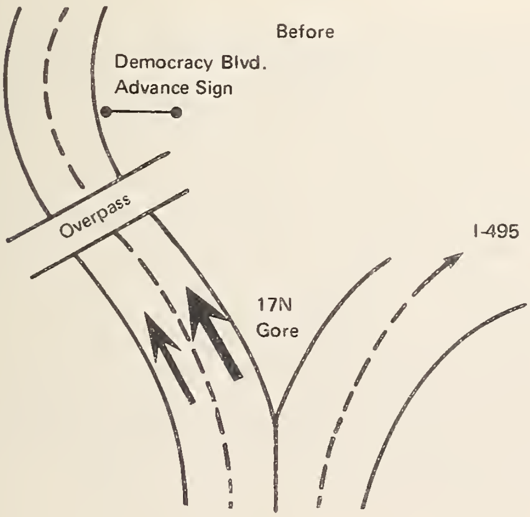
Movement patterns unchanged but frequency of preparatory movements (out of Lane 1) increases. This is significant for one of the two matched days.

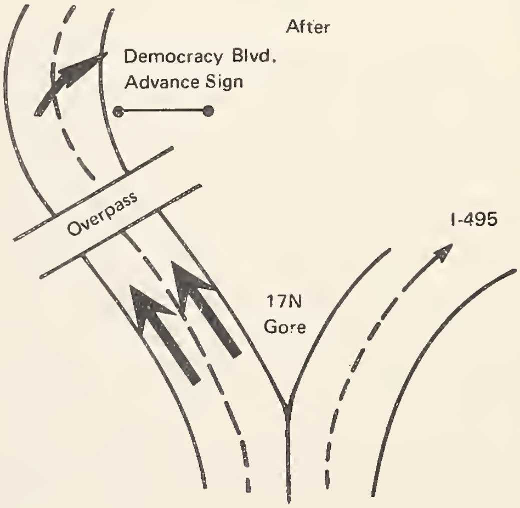


The improvement seen at this interchange was confirmed by a special study of Labor Day traffic using time-lapse films of the gore and exit direction sign locations. Significant reductions in erratic maneuvers were found at the gore for both exiting and through traffic. The benefit for through traffic was, if anything, greater than that for exiting traffic. At the exit direction location, preparatory and through maneuvers were significantly reduced, similar to the results of the main Before/After study. No data were taken at the advance sign location.

Residual effects of the change in exiting traffic behavior at the gore of 17 North probably account for an interesting finding at the advance sign for the Democracy Boulevard interchange. This advance sign is located immediately (within 1/4 mile) after the 17 North gore but cannot be seen until vehicles pass through the gore area. Road curvature at the advance sign restricts sight distance so that the Democracy Boulevard exit direction and gore signs cannot be seen.

At the advance sign, a significant increase in preparatory maneuvers was found. However, *the advance sign was not changed.* It should be noted that about 20 percent of the traffic exits at one of the two Democracy Boulevard off ramp. A hypothesis which is compatible with the increase in preparatory maneuvers in the absence of a change in signs is that repositioning of vehicles at the gore of 17 North resulted in a larger proportion using the median-most lane. If some of these repositioned vehicles contained drivers planning to exit at Democracy Boulevard, then the increase in preparatory maneuvers would be a natural consequence. If this hypothesis is true, it underlines the importance of a systems approach to interchange design and signing. Changes made at one interchange may have downstream consequences. Further study should be given to this area, particularly alternating left and right interchanges within very short segments of highway such as 17 North and Democracy Boulevard.





From the questionnaires, motorist response to the diagrammatics was very favorable. Ninety-three percent indicated that they preferred the new signs. Seventy-six percent felt that they helped the average motorist much more than conventional signs and 17 percent felt that they helped the average motorist a little more than conventional signs. Only seven percent selected the neutral or less helpful categories. No significant differences were found relating sex and age to difficulty with the signs. However, it was apparent that as driver experience with diagrammatic signs increased, the likelihood that they would have trouble with the signs decreased.

With regard to license plate as an indicator of route familiarity when used to separate subpopulations of familiar and unfamiliar drivers with the Traffic Evaluator System, this indicator was found to be poor. From the questionnaire data, of all drivers with nonlocal plates, 39 percent had driven the route six or more times and 13 percent had driven it more than 20 times. Similarly, 39 percent of all those with nonlocal plates had driven the route within the previous 30 days.

The questionnaire data on license plate and route familiarity are a composite of exiting and thruput respondents and thus do not necessarily represent the actual relationship between license plate and familiarity for through vehicles. For exiting vehicles, however, they clearly show the inadequacy of the license plate indicator at the test locations. The finding of little difference in nonlocal and local subpopulations on performance measures derived from Traffic Evaluator System data is therefore not surprising.

Acclimation phase results at 17 North were mixed. The only consistent change was a reduction in erratic maneuvers across the gore and its extension line by vehicles continuing on I-495 (through traffic). This reduction was found immediately after signing change and continued through the Acclimation phase data collection interval.

At 16 South, a significant increase in through maneuvers was found at the advance sign location with the TES and continued through the data collection period three weeks later. Similar results were found in the main Before/After study. At the first gore, proportionately fewer vehicles entered and exited the array in the lane which would drop at the second gore but this effect was not found three weeks later. The Acclimation phase performance data at both interchanges thus showed little evidence of a novelty effect in terms of either an improvement or disruption in behavior. Possibly, however, when the improvements found in the After phase at 17 North are compared to the Acclimation phase data, the disparity is accounted for by a disbeneficial novelty effect on local traffic accompanied by a beneficial effect on unfamiliar traffic. Unfortunately, the inadequacy of license plates as an index of familiarity did not permit partialling out different effects of the signs on familiar and unfamiliar driver subpopulations.

The Acclimation phase questionnaire data showed that the motorists did notice the new signs and generally liked them. Their comments were enthusiastic and provided no evidence that the sudden sign change had caused confusion or resulted in their missing intended exits, being involved in near accidents or other disruptive effects.

In summary, the only interchange where diagrammatic signs were associated with sizable and significant improvements in performance was 17 North. This interchange is a left exit major fork with about half the approaching population exiting. Changes at the gore appear to be attributable to changes initiated at more upstream locations, particularly at the advance sign.

No clear evidence for an overall disbeneficial effect of the diagrammatic signs was found at any interchange. Rather, results at other interchanges showed no effect of the change in signs or mixed results depending on the measure used or small benefits for one subpopulation or another.

References

Alan M. Voorhees & Associates. Freeway signing concepts and criteria. Washington, D.C., June 1966.

Automobile Manufacturers Association. 1969 automobile facts and figures. New York, 1969.

Baker, W. T. Evaluating the traffic conflicts technique. Office of Traffic Operations, Federal Highway Administration, Washington D.C., undated.

Bergum, B., & Klein, I. C. A survey and analysis of vigilance research. Report No. 8, Human Resources Research Office, Washington, D.C., November 1961.

Eberhard, J. W. Driver information requirements and acceptance criteria. *Highway Research Board Record*, 1969, *265*, 19-30.

Forbes, T. W., & Holmes, R. S. Legibility distances of highway destination in relation to letter height, letter width and reflectorization. Highway Research Board, Proceedings of the Nineteenth Annual Meeting, Washington, D.C., 5-8 December 1939, 321-335.

Guilford, J. P. *Psychometric methods*. (3rd ed.) New York: McGraw-Hill, 1954, 395-398.

Hanscom, F. R. Evaluation of diagrammatic signing at Capital Beltway Exit No. 1. Virginia Highway Research Council, Charlottesville, Virginia, September 1971.

National Joint Committee on Uniform Traffic Control Devices. Manual on uniform traffic control devices for streets and highways. U.S. Government Printing Office, Washington, D.C., 1961.

National Joint Committee on Uniform Traffic Control Devices. Manual on uniform traffic control devices for streets and highways. U.S. Government Printing Office, Washington, D.C., 1971.

Oglesby, C. H., & Hewes, L. I. *Highway engineering*. New York: John Wiley and Sons, Inc., 1963.

Perkins, S. R., & Harris, J. I. Traffic conflict characteristics—accident potential at intersections. Research Publication GMR-718. General Motors Research Laboratories, Warren, Michigan, December 1967.

Roberts, A. W. Diagrammatic sign study. Final Report. Bureau of Safety and Traffic, New Jersey Department of Transportation, in cooperation with the Federal Highway Administration, March 1971.

Snyder, J., & Crosette, J. G. Test of diagrammatic sign at Interstate 30 and S.R. 93. Arizona Highway Department, Traffic Engineering Division, June 1969.

Solomon, D. Accidents on main rural highways related to speed, driver, and vehicle. U.S. Government Printing Office, Washington, D.C., July 1964.

Spicer, B. R. A pilot study of traffic conflicts at a rural dual carriageway intersection. RRL Report LR410. Road Research Laboratory, Crawthorne, Berks, England, 1971.

Wyoming State Highway Department. Evaluation of diagrammatic signing. Traffic Engineering Department, undated.

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